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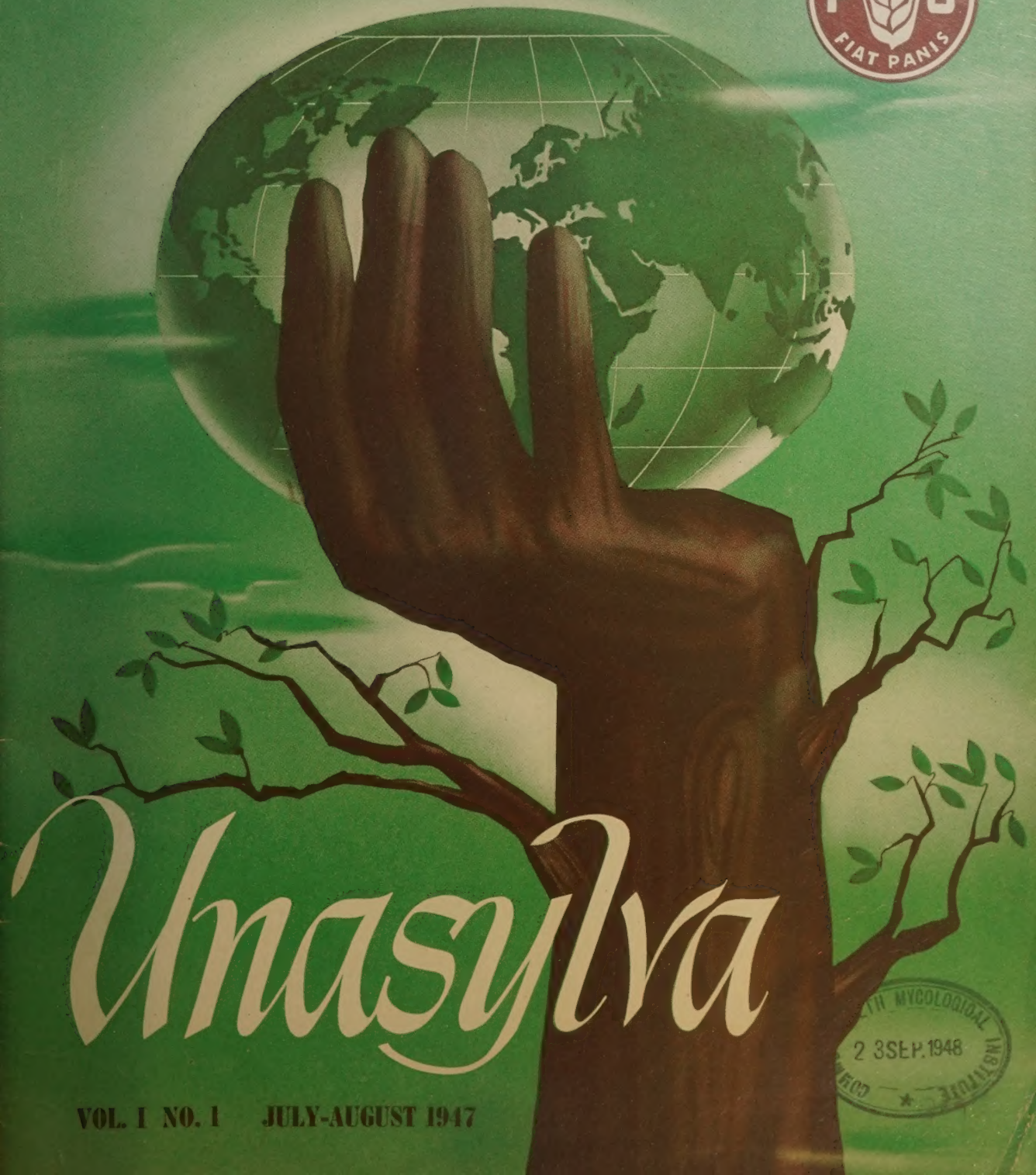
FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS



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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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"UNASYLVA"

THE international forestry review of FAO's Division of Forestry and Forest Products needed a title.

It was felt that the title should express a policy. By going back to a language that once united scientific thinking, the Division has sought to enhance the basic concept that there must be united thought and effort if the "one world" is to consider its forests as "one forest" for the use of all mankind.

The rapid evolution of world economy and the very circumstances of our present lives demand such a policy.

Forests were originally a huge reserve out of which each man could help himself to meet his own most immediate needs: fire and shelter.

As villages and towns developed, the inhabitants had to go farther and farther afield to find the wood they needed. Economically the woodlands could no longer be considered the exclusive and unrestricted property of the individual. To take undue advantage of them was to deprive the community of an essential supply, not only exhausting a source of valuable raw material, but also depriving the tilled soil of an indispensable complement and a necessary protection.

When roads and railways developed, the immediate proximity of vast forests was no longer necessary, and the modern city dweller drifted farther and farther away from the land which nevertheless continued to ensure his subsistence. By that very fact, however, the responsibility of the forester has increased, expanding to regional or even national boundaries.

Meanwhile, nations pursued their destinies. Wherever the population increased, the forests inevitably disappeared —a natural consequence all too often made more serious by reprehensible negligence. In our own times, when so few nations can provide for their own needs of wood, the uses of timber are becoming increasingly numerous and essential to civilization. Timber has now become an international commodity, crossing frontiers, and even oceans. The smallest forest owner has become accountable to the whole world.

To meet her needs, Europe, for instance, must now turn to countries far removed indeed: to the vast resources of the Americas, to the virgin forests of the Soviet Union, to the scarcely tapped riches of the equatorial regions.

Every tree, every patch of forest has become the whole world's concern. Care of the forests then becomes the whole world's responsibility, at least to the extent of affording to governments and forest owners such assistance as may be needed in this often difficult task.

For if forests are now to be considered as a world resource, either as a source of timber or as a general protection for agricultural lands, the world must manage them with all the forethought of a paterfamilias. At the very least, it should encourage careful management. Each generation which has enjoyed this great heritage should pass it on intact, if not improved, to the next one.

This assistance, which may assume many forms, will have to be rendered by international organizations to those who act as stewards of these riches.

The Division of Forestry and Forest Products can only hope that *Unasylva* will serve this purpose by discussing the problems and helping to broadcast the increasingly complex information and knowledge required for a full utilization of the forest and its products.

Division of Forestry and Forest Products of FAO

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One World—One Forest

By SIR JOHN BOYD ORR

Director-General of the Food and Agricultural Organization of the United Nations

THE tie between forests and the good things of the earth runs back through history.

"The glory of Lebanon shall come unto thee, the fir tree, the pine tree and the box together," wrote the prophet Isaiah. Solomon the King sang of "a fountain of gardens, a well of living waters, and streams from Lebanon." There are in the Bible more than a hundred references to the cedars of Lebanon and countless other references to the richness of the land lying near them.

Today those forests have gone, and the once fruitful countryside is an arid waste. There is a story of the shocked surprise of the late President Roosevelt, flying to Tehran, upon realizing that the bare waste of rocks below his plane was all that remained of Lebanon's cedars and the one-time heart of the biblical land of milk and honey. The impression bit deep and was an added reason for the United States's firm belief that the projected Food and Agriculture Organization should have a strong forestry division.

In recent months my own experience has underscored the link between forests and human well-being. On my last two trips through Europe, I saw on almost every hand what war had done to the people's homes. I became convinced that next to the great crisis in food, the housing problem is the most widespread and pressing emergency for cities and towns on the Continent and in the British Isles. The crying need is for lumber.

The recent timber conference in Czechoslovakia was an effort to speed and stimulate the great task of reconstruction that lies ahead. I am glad the delegates at that conference were able to agree on constructive plans for co-operation among governments to alleviate the timber shortage and for attention at the same time to longer range problems of maintaining and restoring forests.

There are many other examples, but these two instances show the place of forestry in the work of FAO. In the long march of civilization man has always looked to the forest for many of his necessities and comforts. In our complex modern world, wood continues to stand first as a building material, is indispensable as fuel, and supplies practically all of the world's paper and a host of other essential industrial materials. Recent discoveries in ways of treating and using forest products may be bringing us to the threshold of a great new era in the use of wood. Moreover, forests are now universally recognized as guardians of soil and water, exerting a tremendous influence for good or evil over field agriculture in all parts of the world.

THUS, forestry and the use of forest products are inevitably and inseparably a part of the work of FAO. The fundamental aims of FAO are set forth clearly in the Preamble to the Organization's Constitution. These aims are—first, raising levels of nutrition and standards of living of people everywhere; second,

bringing about more efficient production and distribution of all food and agriculture products; third, bettering the condition of rural populations; and fourth, as the end result of these three great lines of effort, contributing toward an expanding world economy. FAO could not make a well-rounded effort to reach any of its major objectives without full attention to the forests and their problems.

In the fields of forestry and forest products the forty-eight nations working together through FAO are following a world policy with three main objectives—the conservation of all forests that perform useful social or protective functions; wise use of the world's forest soils for continuing an adequate production of raw materials; and new and better ways of processing and using forest products as a means of raising standards of living.

In forestry, as in its other fields, FAO is not interested solely in studying and solving technical problems for their own sake. Instead, our work in forestry is part of the broader stream of FAO's work as a whole. The FAO Mission to Poland, for instance, will give attention to that country's forest resources and possibilities.

ON a world-wide basis, the problems of forestry and forest products offer a great challenge. One set of problems concerns the present emergency arising from the devastation and disruption of war. At the very time when the need for lumber to repair war damage and for the building of millions of new homes and other structures is reaching its height, the capacity of the currently accessible forests has become insufficient to meet these extra demands. During the next few years, the increased cuttings from present commercial forest areas must be made with as much attention to long-range conservation as possible, and meanwhile, new forest areas not hitherto exploited must be brought into production.

The second and long-range world forest problem is that of keeping pace with growing demands for lumber and other forest products, and at the same time seeing to it that forests are in a condition to continue to produce. The world already has experienced far too much of wasteful and heedless forest exploitation. The depressing cut-over areas of both hemispheres are only one indication of the physical and social ills that follow upon this course.

Both the short-range and the long-range problems call for world-wide efforts. The tasks are too large for any one man or group of men, or any one nation or small group of nations. Already, what happens in Europe makes its effects felt in the forests of Siberia and of North and South America. Just as it is becoming clear that the diverse lands and peoples of this troubled planet form one world, both literally and figuratively, so it becomes clear that the world's forest areas are in reality one forest. FAO's part in the task that lies ahead is that of co-ordinating, stimulating, and guiding the work of public and private institutions in many lands. FAO, in turn, will be only one of many agencies co-operating in the work.

The name of FAO's new magazine, *Unasylva*, is well chosen—one world, one forest. This new review will attempt to shed light on all manner of problems in the field of forestry and forest products, to compare methods that are being used in different countries, and to present the opinions and suggestions of experts in the various fields. I hope and believe it will be a keen new blade in the world-wide battle for freedom from want.

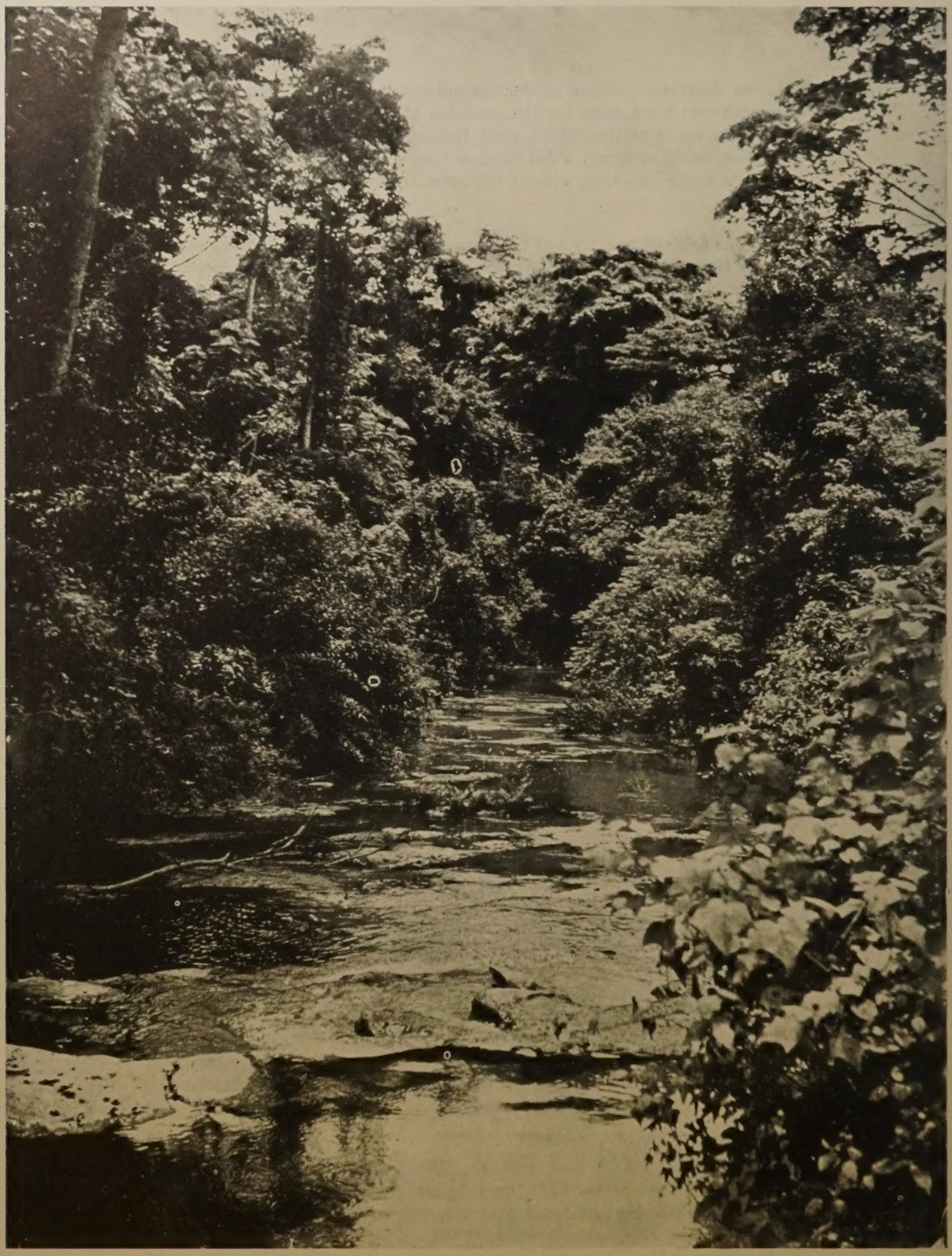

Fig. 1. Riches of the tropical forest

The Disappearance of the Tropical Forests of Africa

By ANDRÉ MARIE A. AUBRÉVILLE
Conservator of Waters and Forests of France

A GLANCE at a map showing the distribution of vegetation in Africa focuses attention on a large patch of green centered in the equatorial zone. This green area represents a vast expanse of dense forest 4,800 kilometers wide, stretching from Sierra Leone to the great East African lakes, and covering parts of Liberia, the Ivory Coast, the Gold Coast, Nigeria, the Cameroons, French Equatorial Africa, and the Belgian Congo.

This enormous forest area would appear to present an almost unlimited reserve of timber to be drawn upon at will, if not today, at least in the future, whenever the world's timber requirements become so great that the temperate zone can no longer satisfy them.

The Equatorial Forest

The equatorial forests of Africa have been little exploited and they contain phenomenal quantities of timber. They cover areas having a particularly favorable climate: there is abundant rainfall spread evenly over the year, except for an occasional short period of drought lasting three months at the most; the temperature remains at an average of 25°-26° centigrade; humidity is very high and there is seldom a lack of moisture in the air. Such conditions are scarcely enjoyable for man but certainly afford a most suitable environment for forest growth and industrial crops like palm, and they produce here the highest yields of oil, rubber, cacao, coffee, and bananas.

Decline of the equatorial forest belt.—Outside this central zone, Africa is devoid of great forest areas. On a large scale map the few forests of French Guinea, Uganda, Kenya, Tanganyika, and Angola appear as insignificant dots, and, therefore, over the whole area of tropical Africa, the average density of stocking is low despite the size of the forests of the humid zone.

In studying Africa's climate one is surprised to discover that over a fringe from a few dozen to two or three hundred kilometers in breadth around the equatorial forest zone, the climate is the same as that prevailing in the forest. All the climatic conditions favoring a dense, humid forest are there, and yet one finds vast prairies of tall grasses, sometimes dotted with shrubs or small, scattered trees, sometimes bare of any such vegetation. They alternate with areas supporting food crops or are interspersed with patches of high forest.

Considering that plant types are conditioned by environment and more particularly by climate, these forest borderlands constitute an astonishing anomaly.

In view of these dense forest stands adjacent to savannah land, the natural assumption would be that the forest "climax" type, favored by climate, was slowly encroaching on the grassland, and that we were witnessing an ecological transition.

This explanation is, however, inaccurate. The African continent is an old insular shelf that came into existence in primeval times. The forest has had ample time to occupy all areas having favorable environmental conditions. One has only to realize the speed with which it is capable, even today, of invading recent alluvial deposits, to agree that this is so.

A study of the woody flora of the borderland savannahs points conclusively to forest regression. The small trees and shrubs which have established themselves on the savannahs belong to a few species only. They are members of a common light-demanding plant community to be found in open spaces throughout tropical Africa. Here they are alien species which have emigrated from regions having a drier climate. Their hardiness, the ease with which they propagate, their resistance to destructive factors, their ability to throw out new shoots and suckers give them that power of extending their range which is common to all weeds. They do not belong to the dense-forest flora and in any case could not survive under the closed canopy.

Reasons for the forest regression.—How did the regression from high forest come about? The process continues to unfold before our eyes.

The primary cause can be ascribed to the clearing done by native populations who, living in a compact, unbroken forest, are forced to cut down trees in order to allow the sun to reach their crops. These clearings are not peculiar to Africa. In all tropical countries

natives use the same methods of preparing land for cultivation. They fell trees and burn them and set fire to those left standing. After one or two crops, they abandon the exhausted soil. A low, dense growth of shrubs, small trees, and creepers, termed secondary scrub, rapidly invades the cleared space. It consists of species different to those of the original forest. The natives meanwhile start clearing further tracts of forest where the humus and soil, enriched by wood ash from burnt vegetation, will provide adequate crops.

The primitive nomadic method of agriculture has been practiced by all native populations since time immemorial, and the original forests have, for the most part, been replaced by secondary forests. The latter, provided conditions are favorable, may slowly revert to the original type but such is not always the case. Recovery is poor when the soil has become extremely impoverished, where slopes are worn away by erosion, or where local climatic conditions include a dry season particularly long and arid. In such cases the soil covering, instead of secondary forest, often becomes savannah-type grassland or brushlands.

The virgin forest is not prone to fire, but the stunted secondary scrub, the savannah and the brushland becomes sufficiently desiccated during the dry season to be inflammable. Fires raging every year over the savannah manage to penetrate each time a little further into the high forest by attacking the grass-type plants and secondary scrub which do not resist the flames.

Forest regression is very noticeable where, as frequently happens, the local native population concentrates on clearing land on the forest edge, thus opening up gaps through which the fires can penetrate; or in hilly areas where crops are planted on rather steep banks covered only with a thin layer of soil.

It is for these reasons that the forest borderland zone now exhibits such varied characteristics: scattered remnants of the primeval forest, not yet attacked or protected against fire by accidents of topography, such as rocky ridges or very humid valleys; thickets of low scrub, remains of the former secondary scrub that followed land clearings; areas covered with tall grasses and savannahs, bare except for a few tall half-burned trees, bearing witness to recent clearing; older savannah land already supporting shrubs and small trees belonging to an alien xerophilous flora.

Characteristics of the older regression and present conditions.—At present, two factors with conflicting tendencies are affecting the rate of disappearance of the dense African forest.

Native populations, in general, tend to move from savannah lands to the forest, first settling around the outskirts, then pushing back the forest limits. Gradually they reach portions of the forest which are increasingly humid and have a greater power of recovery and resistance to fire. The spread of savannahs tends in this way to slow down, as compared to the past when settlers were dealing with less resistant forests under drier climates; the further the advance towards the heart of the equatorial forest, the more the transformation into savannah is held in check. On the other hand, intensive land clearing has become more general with the present-day development of agriculture, particularly of industrial crops, and certain populations have increased in density while economic development in general has given rise to constant shifts in populations, thus increasing the burden on forests.

The contraction of the high evergreen forest may appear slow. There are those who deny that anything of the sort is taking place because they notice no appreciable change from one year to the next, except for occasional nibbles at the forest outskirts by brush fires which, on dry soils, may sometimes succeed in penetrating the understory for some yards. In fact, the surrender of the forest to the savannah is spread over vast areas around the perimeter. There is, as it were, slow deterioration altering the landscape in a manner impossible to detect over short periods. Somehow the forest dissolves almost imperceptibly into savannah.

In the past, this was not always the case in drier areas likely to be cleared for cultivation. Ground fires were likely to spread directly to the understory and even to the forest canopy. Forest decay was then definite and rapid. It is because all the forests that could easily be set on fire were burned out long before Europeans ever arrived that, today, in regions having a climate more properly belonging to a forest climax, we see in contrast either savannah land, bare or supporting an alien flora, or the high evergreen forest, well able to protect itself against man's incursions and the fires which lick at its fringes. The equatorial forest is still diminishing today but at a much slower pace than before.

Were it not for the annual ground fires, the forest would of itself regain much of the ground that it has lost. Every experiment so far demonstrates that recovery is rapid when the soil has retained its humus content and a good structure.

Certain observers have reported cases of the forest extending its range, but what this presumably means is rather that the forest has re-established itself where particular circumstances have arrested the ravages of the annual fires.

Clearing the high evergreen forest eventually produces important modifications in the composition of the forest growing stock. The species of the virgin forest tend to be replaced by rapidly growing light-demanding species. In certain fortunate cases the latter are economically more desirable than the former, as for instance with gaboon (okoumé), *Aucoumea klaineana* Pierre, in Gabon, and *Juniperus procera* Hochst in burned areas of high altitude forest in East Africa.

Dry forests and wooded savannahs.—The equatorial forests form an impressive mass in the heart of Africa but represent only a small percentage of the total land area of the continent, even when we exclude the Sahara, the maritime deserts of the Somali Coast and the west coast of southern Africa.

Tropical Africa, which has two well-defined seasons, the rainy season and a long dry season, is covered with vast stretches of wooded savannah, and with open forests of small-sized trees, which at times grow close enough together to resemble forests of the temperate zones, forests in which, however, there would be a soil covering of grasses.

Each year at the beginning of the dry season, this country is swept by fires. These, however, are only ground fires. Trees and shrubs may have their foliage singed but as a rule escape burning. In the wake of the fires, the earth lies covered with a black dust of carbon and ashes and the tree stems appear scorched.

Nature seems dead, but should rain fall or dew form a few times, a soft haze of grass covers the soil and the trees turn green again. Nature comes alive, fairer even than before the coming of the flames, when only dried and withered leaves were to be seen.

Each year the same phenomenon is repeated. It seems as if things had always been so, but that is not true.

Actually, we are witnessing the death struggle of a plant world, slow stages in the drying up and degeneration of tropical Africa.

The insidious thing about it is that, generally speaking, nobody seems to realize it, in much the same way that the friends of a very sick man, who has been an invalid for years, get so used to seeing him in an ailing condition that they forget that once he was in perfect health. They cease to perceive the slow encroachment of disease until one day the sick man dies.

In Africa, it is now taken for granted that fires, savannahs, and sparse forest stands constitute a state of equilibrium which has always existed. Certain geographic ecologists, who do not yet fully comprehend the biological evolution of these associations, call these wooded savannahs a "climatical" type of vegetation.

Yet a look at these trees and shrubs suffices to show the damaged, stunted boles and the scraggy tops unable to develop normally because the branches are scorched each year, and to prove that the young shoots and seedlings are annually consumed by fire except for a few that manage with difficulty to survive.

It is only because the plants have such remarkable vitality and such power to throw out shoots and suckers and to develop a thick and often corky bark that this woody vegetation survives at all.

The naturalist, however, can but wonder at this unnatural association of grasses and trees—the grasses tend to smother seedlings and young plants and the shade of the trees tends to kill the light-seeking grasses.

If it were not that the annual fires kept the forest cover open and allowed the grass to regenerate, the latter would disappear in a matter of years or centuries, depending on the particular environment.

The typical African landscape of wooded savannahs is artificial, except in the desert borderland areas. It has come into existence from the effects of fire and clearings on the old, dense, close-canopied high forest, with shrubby understory but with no grass undergrowth, a forest of a type altogether different from the humid equatorial forest but the formation of which is lost in the mists of time.

All the forests which in the past covered the arid regions of Africa with a huge unbroken mantle have today ceased to exist, save for a few traces that have to be painstakingly tracked down in uninhabited areas; there, however, it is a surprise to find in closed communities all those species of trees and shrubs that are customarily found in isolated stunted groups on the wooded savannahs. This is their real habitat. Here species are associated together according to climate and soil, whereas ordinarily they seem to be thrown together haphazardly with no apparent reason. There is a compact understory of shrubs, woody climbers and creepers below a forest canopy, varying in height from 12 to 20 meters, sometimes closed, sometimes partly open, depending on the soil. Various tree associations are to be found with some particular dominant species, for instance, with *Anogeissus;* with *Isoberlinia–Uapaca–Monites;* with tall leguminous *Burkea–Erythrophleum tetrapleura–Prosopis;* with *Parkia–Pterocarpus;* with *Brachystegia–Isoberlina;* with *Cryptosephalum;* with *Detarium–Parinari–Afzelia;* with *Combretum–Terminalia;* with *Anogeissus–Boswellia.* Such associations are still to be found forming sizable forests in southern Africa (Northern Rhodesia, Katanga, Angola), and to a lesser extent in Ubangi-Shari, in French Guinea, and in Casamance.

These latter stands will sooner or later disappear. The process can be watched, as the clearing of land for cultivation proceeds. Sometimes fire alone is sufficient to destroy the forest. The undergrowth is most vulnerable to fire during the dry season. Fires generally sweep along lanes into the forest according to the direction of the wind and the degree of dryness of the jungle. The more resistant patches are left isolated. Grass species immediately establish themselves in the clearings and in the following season feed anew the flames and help the fires to spread further. The dominant trees are more or less able to resist because of the protection afforded by their thick bark and their deep root system. Nevertheless they often suffer damage at the base and the cumulative effect of several seasons' fires accounts for a great many of them.

Thus the forest is gradually thinned and reverts to grassland. In the course of centuries savannahs tend

Fig. 2. Remnants of the dry forest

to replace the forest and the latter would have long since vanished had it not been for the exceptional vitality of some of its component species which manage to survive in spite of all adverse circumstances. But as long as fires remain an annual occurrence, the forest will continue to deteriorate.

The native tribes set fire to the land for numerous, more or less justifiable reasons. The tall, dry grasses are an obstacle to the native African. They impede his movements. They hinder him in hunting and in growing crops, and the simplest way to get rid of them is to set them afire. In reality, of course, the more the land is cleared, the more easily the grasses spread, but the bushman does not look ahead. He only tries to solve his immediate difficulties. The grasses smother him, so he simply sets fire to them.

In the same way primitive man set fire to the dry high forest. Tangled thickets, creepers, and thorns were not easy to penetrate. The first fires were kindled so that man could move about more freely.

As populations increased, as wars broke out between tribes over the possession of hunting or fishing grounds, the migrations of both conquerors and vanquished multiplied fire hazards.

Later, agriculture and stockbreeding developed and farmers and shepherds, in their turn, cleared land and set fire to the forest.

These developments, which changed the face of Africa, date back to a time so far distant that no memory of them is left. The change was complete and general. Were it not for the forest areas that have survived, it would be difficult to imagine how things had once been.

Consequences of the Disappearing Forest

Effect on Timber Production.—In general, it can be said that tropical Africa is tending to become savannah. Economically, for both local and world forestry, this tendency must have serious consequences.

Except for the equatorial forest regions, Africa already imports timber. Further progress and increase of its population will only make this situation worse. Where the climate is dry, haphazard clearing around centers of population has already resulted in a total disappearance of woody growth. Now the women of a community are often obliged to walk for hours in order to gather firewood which they will have to carry back to the village; otherwise they must buy their firewood for cooking at a high price in the market place. Timber has become scarce; straight-stemmed trees are to be found only along far distant riverbanks. The problem of wood shortage has to be faced everywhere in these dry, populated areas, and the problem is indeed trying for both the local population and the administration.

The resources of the great equatorial forests, on the other hand, greatly exceed the needs of the local population. They are being used for a far from negligible export trade, which could grow in importance on the Ivory Coast and the Gold Coast, in Nigeria, the Cameroons, Gabon, the central Congo region, and the Belgian Congo.

Timber reserves are still very considerable, compared with the relatively insignificant quantities now taken out for export. The outlook for the future, however, is disturbing since each year, as further land is cleared, part of these reserves go up in smoke.

Secondary growth of medium and small trees covers larger and larger areas as time goes on. The timber is soft, nondurable, and good for no particular use. On the average, one- to two-thirds of the forest area consists of secondary growth of no great value.

When the shortage of timber forces the world to start giving serious consideration to African woods, the vaunted equatorial forests might only be able to supply an insignificant contribution to world production, unless precautions are taken now.

In certain areas, however, climate and species offer wonderful possibilities for rapid growth of timber. It would be possible by very simple silvicultural methods and with no great financial outlay to establish rich forests on the coastal areas of the Gulf of Guinea, from the Ivory Coast to Gabon.

Effect on Living Conditions in Africa.—The effect of the disappearance of the forest on living conditions in Africa is far more serious than its effect on timber production, since the future of mankind on a whole continent is at stake.

The removal of the forest cover influences the climate, soil conservation, and water reserves far more than would be the case anywhere else in the world.

To begin with, as was mentioned earlier, we are dealing here with a general phenomenon which affects the greater part of tropical Africa and thus assumes the proportions of a major factor in regulating climatic conditions.

For the duration of the dry season, lasting from four to nine months (except in the desert and desert borderland countries), the bare, scorched earth is exposed to the sun's intense heat and is subject to a high rate of evaporation, caused either by the direct heating of the soil or by the dryness of the atmosphere and the desiccating winds that prevail during this season.

The major result of this dry heat is a change in the physical structure of the soil, making it less resistant to the forces of erosion which are set in motion by the violent rains ending the dry season. There is also a fall in the water table which, though made up to some extent by later rains, still affects the total water supply for the year.

The exposure of the soil to excessive heat, followed by severe leaching, leads to erosion in all its forms: gully erosion and sheet erosion, loss of productivity through the burying of humus, and the disintegration of the colloidal structure of the soil—all important elements in soil fertility. The African soil deteriorates with a rapidity unknown in temperate zones where exposure to the sun is less intense and of shorter duration. Deterioration is also accelerated by the loss of carbon and nitrogen as a result of the burning of the vegetation during the period of ground fires.

For the reasons enumerated above, the crops of the native farmers yield very little. There are, generally speaking, no fertilizers to replenish the soil, and as a result, Africa is a poor country agriculturally. The natives hardly question this state of affairs, having long since become accustomed to meager crops. When the soil is exhausted in one place, they can move and clear further areas of forest. Wooded land is still to be found where, although the trees have deteriorated,

the soil is still capable of cultivation. Thus the process will continue so long as virgin soil remains to be cultivated, but it cannot go on forever.

One odd result of erosion, following deforestation, can be seen in certain regions of undulating plateaus. Beneath the topsoil are found hard ferruginous and lateritic strata, probably of fossil origin. When the surface soil wears away, these strata are exposed and harden into a ferruginous or lateritic shell which will support no vegetation other than barren grass. Such regions (French Guinea, Ubangi-Shari) acquire a semidesert character in spite of abundant rain.

Effect on Precipitation.—Africa is a continent badly situated with regard to the major atmospheric currents. On the Atlantic coast, the marine trade winds veer off in other directions; in the north Atlantic, they are diverted and blow from northeast to southwest; in the south Atlantic, they blow towards South America, from southeast to northwest. The trade winds are diverted by the low pressures over the continent and only cool the coastal regions; they bring no rain but merely humidity and fog.

During the Northern Hemisphere winter, North Africa is swept by dry winds coming from the Sahara. These are continental trade winds, called "harmattan" in West Africa and the "Egyptian current" in the Nile region. They exercise a drying effect up to the Gulf of Guinea in West Africa, and to the Equator and even beyond in Central Africa. Northeast Africa receives the Asiatic winter monsoon. This wind is usually dry but, after passing over the Indian Ocean, it brings a few light winter rains into Eritrea and Somaliland.

During this same time of the year, Southern Africa, where it is the warm and rainy season, is under the influence of the Indian Ocean trade winds, which blow in a general southeast to northwest direction. They cause rain to fall on the coastal areas, but they dry up rapidly and bring little rain inland. During the southern winter (northern summer), they are drawn to the overheated Asiatic continent and, by avoiding Africa, are drawn into the powerful air currents of the Asiatic wet monsoon; East Africa, however, receives very little rain.

Thus while Africa gets little benefit from the major air currents emanating from the sea, it is much exposed to dry, continental winds, which absorb its moisture reserves, or to sea winds, which have lost their water content. Fortunately, there is one important exception, without which Africa would have dried up long ago. The equatorial Atlantic monsoon, blowing from the southwest towards the continent, brings abundant summer rains. Drawn inland by low barometric pressure, it penetrates far into the heart of the continent up to the southern borders of the Sahara and crosses the continent to Abyssinia.

The amount of rain originating from the sea and brought in by the monsoon is important, but experiments carried out in Africa to determine the proportion in rainfall between water vapor from ground evaporation and from sea winds, have shown that over half, or even two-thirds, originated from ground evaporation.

Evaporation from the ground is governed by the water reserves in the soil. Anything that tends to decrease the latter affects the former. Deforestation involves the loss of soils that constitute reservoirs for the accumulation of water. It exposes these soils to evaporation and to desiccation during the prolonged dry season, so that it cannot but decrease Africa's water reserves and, in the long run, the amount of precipitation.

The dry forests which once covered the major portion of tropical Africa are not of much importance as

Fig. 3. Remains of the forests of Madagascar

far as timber production is concerned, except locally. Their role consists in protecting the soil against erosion and desiccation during the dry season. Their disappearance from whole areas probably has had, long before the present age, a continuously unfavorable influence on the climate and undoubtedly has had disastrous effects on the soil.

The diminishing surface of the equatorial forests has also had other results. A vast forest mass can affect the climate through the great amount of moisture it releases into the atmosphere from evaporation, and which not only gives rise to local rainfall but also increases the amount of precipitation in the warmer deforested areas surrounding the forest. Early in the century a study was made of the influence of forests on rainfall in Europe. Experiments were confined to one particular forest and the results were inconclusive. They could not have been otherwise. Only immense stretches of forest land, such as are found in equatorial areas, are capable of producing sufficient evaporation to exercise a climatic effect. Furthermore, the moisture thrown off by evaporation from a forest is often carried long distances by air currents before becoming condensed and precipitated as rain.

Masses of equatorial forests help to keep dry areas moist and to increase the amount of rainfall in such regions even when they are located quite a distance away. Their effect is comparable to that of the sea or of great lakes—the presence of the equatorial forest approximating climatically that of deep ocean gulfs reaching into Africa. The monsoon, blowing inland from the sea, rapidly sheds most of its moisture in the coastal belt and would soon be unable to produce abundant rains in the heart of Africa if it were not reinforced along its course by vapor from large rivers, marshlands, soil, and vegetation. The equatorial forests of the Guinea coast assume their greatest importance at the beginning and end of the dry seasons, when the soil left uncovered by the action of fire or covered with dry savannahs is desiccated on the surface and only the forests can still yield up moisture to the monsoon winds. Without them, the rainy season of the Sudanese regions would probably be of shorter duration.

The amount of rainfall over the southern borderland regions of the Sahara depends directly on the Atlantic monsoon. When the latter is active, rainfall is comparatively abundant. If not, a drought year results and famine strikes man and beast. Additional rainfall at the beginning and end of the dry season depends on the moisture supplied to the monsoon by the coastal forest regions of the Gulf of Guinea.

Drying-up of the climate of inner Africa.—What has been said above regarding the effect of African forests upon environment, makes it probable that the wholesale destruction of inland forests would accelerate deterioration of vegetation and soil in Africa and bring about acute desert conditions.

These changes in the aspect of the vegetation and correspondingly in the environment took place for the most part, as previously pointed out, at remote epochs long before the advent of Europeans. They continue even today wherever there are any forests left.

It is surprising to note the ease with which it was possible for man to set fire to such large areas within periods of time which are relatively short when compared to the age of the forests covering Africa

Resistance to fire varies considerably according to the type of forest. Dense humid forests protect themselves better against all destructive agencies. Certain types of dry, closed, or semiclosed forests are very prone to fire damage. They deteriorate and become open forests or wooded savannahs but they survive somehow and, should the threat of fire be removed, could again become high forests. Other forest communities, on the contrary, may disappear altogether with great rapidity. This is the case, for instance, with the forests of western Madagascar which are almost nonexistent today, with the forests of the lower Congo and the Mayomba in South Africa, of Futa-Jalon in French Guinea, and probably with a great many others. Everything tends to show that these forests, so easy to transform into savannahs, are not in biological equilibrium with the present climate, which has apparently become drier than the climate prevailing during the remote epochs when these forests came into being.

Such a theory is not improbable but it is impossible to prove it by meteorological statistics, since, with few exceptions, such data have only been collected in the last fifty years, a mere fleeting instant in the biological age of the earth. What we do know is that the climate of tropical Africa changed several times during the Quarternary Age and probably also during prior geological ages. Concurrently with the glacial periods of the temperate zones, Africa had alternate periods of drought and heavy rainfall that furthered the formation of deserts and of the equatorial forests.

Remnants of old canal systems in the Sahara, traces of human occupation, certain facts established historically,-and vestiges of a tropical flora south of the Atlas Mountains—all point conclusively to the presence of humid periods. South of the Sahara, in Senegal, the Sudan ,Nigeria, and in Tchad, the sandhills (ergs) now hemmed in by vegetation and the cloak of sand covering vast expanses prove conversely that desert conditions formerly extended south far beyond the present limits. The forest vegetation of West Africa presents a curious mixture of different floras which developed as environment changed with climatic phases. Some have remained to form groups of species which have more or less adapted themselves to new environmental conditions, though their presence seems ecologically abnormal.

On the basis of the evidence found, it is therefore possible that the destruction of forests over the major portion of tropical Africa is only a delayed consequence of the drying-up of the climate.

Forests which had adapted themselves to favorable climatic conditions now no longer existing might nevertheless have survived until today, as indeed some have, thanks to the well-known fact that forests create a special environment of their own favorable to perpetual regeneration and which, in some way, isolates conditions within them from the general prevailing climate. But when the native tribes in Africa began to multiply, fire upset the delicate balance which had been established between the forest and the dry climate. This was the beginning of the disappearance of the forest; the soil became exposed to the all-powerful tropical sun and the desiccating winds.

Conclusions

Deforestation of Africa is going on now as it has been for ages past. At present we are witnessing the finishing touches to a process which probably started before the dawn of history and which reached a climax during the unknown era when the first great invasions of man into Africa took place.

Man has set fire to the forest for the same reason that he has hunted, in order to be able to survive in

the midst of a hostile nature. By destroying indiscriminately, however, he has only added to the difficulties a tropical climate imposes.

Now that the curse which has been plaguing Africa has been identified, it is imperative that measures be taken to counteract the evil.

The African native is heir to all sorts of woes—famine, epidemics, malnutrition, etc. All countries with an interest in the life of Africa are striving to remedy these many misfortunes of the native populations, but it is impossible to better their lot permanently in an environment which is contrary to their way of life.

The social progress of the native population is linked with the development of their agriculture, of the means of production, and of adequate living conditions in their countries. The wholesale disappearance of the forests tends, as we have shown, to make Africa a continent less and less favorable to man's progress, save in a few favored sections.

Is it possible to take adequate measures to protect Africa, its soil and its forest cover? The answer is *Yes*, since the evil and the remedies are known.

Restrictions must be imposed to limit indiscriminate burning and land clearing, and to prevent all unnecessary destruction. In some cases, new agricultural methods must be brought into use; in others, cultivation of any kind must be prohibited. At times, migration of populations from areas that are too arid and too poor towards richer centers should be helped and encouraged. The work of the native population must be made more productive. New resources should be made available to them through the development of crops suitable to the environment. Sometimes reforestation would have to be carried out and often forest protection would be indicated.

In this field, considerable research and many experiments have already been undertaken by various countries, but there is, of course, a wide gap between theory and practice.

In our opinion, the salvation of Africa is a gigantic task, requiring great tenacity for several generations, that can be achieved only if undertaken on an *international scale.* Without a common program, adapted to the requirements of individual countries but carried out simultaneously wherever possible, the governments responsible for Africa will always hesitate to act. Left to their own devices, they will prefer to defer expenditures and the adoption of regulations, and will refuse to advise on actions to be taken if their suggestions are not carried out at the same time by their neighbors, who for some reason might find such an effort too troublesome a burden.

We also believe that however intelligent, praiseworthy, and timely any particular measure may be, if it is applied within geographical limits that are too narrow, it will fail to achieve worthwhile results simply because these would not be commensurate with the scale of the African continent. All African countries are concerned. Forest masses yield an influence over wide distances and what is done in one country may have repercussions in other distant countries.

Pooling of effort, joint research, and the synchronizing of undertakings appear to us imperative if failure is to be avoided.

As a beginning, we believe that, within the framework of the international agencies, an office for the protection of African soils and forests could first usefully be entrusted with the study of all these problems; later this office would become well-qualified to promote policies of protection which should be adhered to by all governments. It would also become the agency empowered to make recommendations and suggest measures which should be adopted, and to keep under observation the evolution of a continent which at present seems doomed to become unproductive grassland or even a desert.

The foregoing article was prepared in the French language, and translated into English by FAO.

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Fig. 1. Sawmill at Yukon, Vancouver Island

Forest Utilization

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THE forest is a dynamic, aggressive organism. A product of natural forces, if left to itself it reproduces, grows, matures, and dies in its component parts, while the over-all composition remains in balance with soil and climate. In a suitable climate it dominates the earth, potentially the most fruitful of all organic resources in its ability to yield varied goods to intelligent use by man.

The forest is composed of thousands of species of trees and it occupies climatic zones from tropical to subarctic; its character is an infinitely variable thing. From the northern forests, where only a very few species compose the whole, to the lush, dense, tropical rain forests made up of hundreds of kinds of trees, there is a variety of material that can be turned to almost any use.

The use to which the forest is put is almost as varied as its nature, but, broadly, it can be classified in the following categories that have regard for the relations that have existed between man and the forest.

1) Relatively abundant forests, heavy population, and intensive use with close attention to the perpetuation of the forest. Examples are plentiful in northern Europe.

2) Relatively meager forests, heavy population, and intensive use with little or no attention to the perpetuation of the forest. Examples are found in Africa and the Near East where continued unwise use has destroyed the forest and the land with it.

3) Abundant forests, relatively light population, and heavy use of the forest, with relatively little attention to its perpetuation. This is a temporary or transition phase, exemplified in North America.

4) Abundant forests, relatively light population, and little use, exemplified in much of the tropics.

The impact of people upon the forest has been most severe in its consequences where the resource was meager, the population heavy, and usage bore no relation to the ability of the forest to maintain itself. It has been least severe where the regenerative capacity of the forest was high and intelligent use of the products of the forest was best integrated with that regenerative capacity. Ways of using forest products changed but little for literally thousands of years, but modern technological practices applied to wood have revolutionized the conception of wood as a raw material. Therefore, with expanding usefulness of wood has come and will come increasing impact of

population upon the forest resource. It becomes of the highest importance to examine the probable nature of that impact and to formulate those practices that will lead to perpetuation of the resource while deriving from it the maximum of material benefits.

It is possible to take advantage of the potential vigorous productivity of the forest in new ways, to harness the true growth capacity of forest lands to old and new human needs, and to increase the yield of goods at the same time because intelligent and planned utilization of the forest crop can be a most valuable implement in raising the level of forest productivity.

Influence of the harvest upon forest crop.—Forest crops are uniquely distinguished from most other products of the soil in that the methods used in harvesting, and thus the character of utilization of the crop, go far toward determining the yield and quality of succeeding crops. If annual growth of wood in usable form be taken as a criterion of production, it is apparent that those methods of harvesting that encourage the highest practical rate of growth will be, in the long run, most remunerative and provide most goods.

The effect of cutting or harvesting methods on the subsequent crop may be altered in a desirable direction by removing species not wanted in the ensuing forest, thus encouraging the reproduction and growth of more desirable species. Such operations are possible and are executed in the management of mixed forests, always with full regard for those basic silvicultural laws governing the varied and complex processes of reproduction and growth. It cannot be said that the science of silviculture is either adequate or properly covered with research activity, but sufficient basic facts are available to make possible rather efficient management of many forest types. It may be confidently expected that continued research will in good time make available the basic structure of silviculture necessary for such management of all important types

The character and amount of the harvest is usually of great influence in determining the subsequent rate of growth of the remaining stand and the composition of the new forest. This is especially true in the cutting of virgin forests where most often there is biological balance, death of old trees, regeneration of new ones, a static forest in which little or no net increment of wood takes place. Many times there may even be net loss. Such forests are prey to insects and disease and represent not a productive mechanism but an accumulated reservoir of wood that must be drained before it can be refilled at a more rapid rate. Such a forest should be harvested, but in such a way that new trees and new growth are ensured with a composition of species desirable in the general economy. This can be done, and is being done, but too often desire for immediate returns causes haphazard and destructive cutting that destroys the forest conditions themselves, eliminates existing young trees from which current growth could be expected, and delays for many years the building of a stock of young, vigorously growing trees. This has been the tragedy of too much harvesting of the virgin forest, especially in North America.

Haphazard selective harvesting of only high quality material over many years has led to the degrading of much originally good forest to types in which there is little left but species and qualities of trees that have not been suitable for conventional use. These conventional uses, clear lumber and pulp, for example, have

Fig. 2. Logs ready for dumping into the mill pond at Grosset, Arkansas

dictated the harvest but the forest has gradually altered in the direction of little or no yield of commercially useful wood. Clearly this unproductive forest can be made productive and capable of furnishing its potentiality of goods only through reversing this process; low quality wood must be harvested in order to encourage reproduction and growth of good trees.

There is ample opportunity for increasing the efficiency of the harvesting operation itself, both from the point of view of its influence on the forest and of reducing the cost of the operation. Imagination and daring applied to the task of cutting and transporting wood ought to produce mechanisms far in advance of the somewhat cumbersome and highly wasteful tools of today. The same idea applies to traditional methods of lumber manufacture with the huge waste of material involved. When the harvest can be conducted cheaply, with the dual purpose of producing goods and maintaining or enhancing the growth of raw material, and subsequent manufacture is well diversified and integrated with the raw material supply, perpetual forestry becomes a realizable fact.

All these processes, whether applied to virgin or degraded forests, involve the removal of wood from the forest in order to increase the rate of production in future years. Such removal of wood costs money and generally the investment is one of long duration, offering a modest earning rate, but realizable only at a distant date. Private capital has not generally been anxious or willing to embark on such enterprises. Governments have done better and, in several ways, have encouraged and executed those types of long-range management required in the handling of forest properties.

Diversified utilization can encourage good forestry.—But, whether governmental or private properties are involved, there is one inescapable fact: opportunity to convert the harvest to goods at even a modest profit is a prerequisite to the execution of the harvest. Within the term "profit" must be included the idea "social gain," for clearly the establishment of permanent industries and communities upon a forest base represents social "profit" of a high order.

If trees must be cut now at a monetary loss in order to provide a better long-range return on capital, incentive to the type of forestry necessary to high production is lacking. Or, to put the matter more positively, the opportunity of recovering even a small present benefit from improved harvesting seems to offer the strongest encouragement to good harvesting practices.

Such harvesting will yield a wide diversity of kinds and qualities of wood highly variable in adaptability for use. Therefore an important impetus to proper harvesting will be given by developing uses for wood, through wood-using industries that can convert all qualities to useful goods. Such uses already abound. They are being exemplified now in many lands, some highly intensive, some more or less haphazard. Rarely are they well grouped into diversified wood-using enterprises, integrated with the kinds and qualities of wood produced by the forest base, but such grouping and integration can be the base for extensive industrialization.

In a broad way, it can be shown that productive forests, planned, diversified, and integrated wood utilization, and a high standard of living accompany each other. Abundant forest resources alone do not suffice; it is the degree to which they are managed for the production of a steady flow of goods that can be associated with good living. By contrast, haphazard forest products utilization has in the past been followed by general lowering of living standards. More accurately, it seems probable that proper application of modern technology to the diversified utilization of the forest crop can make heavy and important contributions to expanding world economy and generally sustained improved living.

Versatility of wood.—Although wood has always furnished a large share of the world's requirements in shelter and fuel and has contributed in a myriad of other ways to man's comfort, modern industrial and scientific practices have been slow in their application to wood. This is not surprising. Wood is the oldest raw material of man's use. Customs of long standing and habits of thought have limited its sphere while newer technical developments were applied to varied mineral products. Thus, the age of steel overshadowed the steady, reliable use of wood in old engineering ways with spectacular industrial developments and structural forms impossible for wood in its traditional modes of use.

In the chemical field, organic chemistry grew great and organic chemical manufacturing developed on a coal tar base. Only recently have successful synthetic chemical industries developed on the straight chain aliphatic hydrocarbons of petroleum. Likewise, comparatively recently have industries begun to thrive upon products of fermentation of carbohydrate materials. These new chemical fermentation industries are opening broad new avenues in the mass production of new chemicals based on sugars, and thus far, sugars are exclusively products of the soil. Coal is limited in the kind of chemical goods that can be derived from it. Likewise, petroleum is limited in its character and labors under the added handicap of being limited in its amount. Coal is relatively abundant but not too well distributed and not freely available nor unlimited in quantity.

Wood combines within itself possibilities as a chemical raw material that parallel those of sugars, coal, and oil, and adds other possibilities unique to wood. In addition, it can fill its traditional uses, and expand its usefulness as a standardized, highly developed engineering material.

Importance of wood in world economy.—It is not surprising that some nations blessed with abundant forests have developed high standards of living. Such nations have based their living upon a perpetu-

TABLE 1.—WORLD PRODUCTION OF CERTAIN IMPORTANT MATERIALS

Wood	1,200 million tons
Coal	1,300 million tons
Petroleum	275 million tons
Steel	135 million tons
Milk	200 million tons
Potatoes	250 million tons
Wheat	150 million tons
Corn	120 million tons
Sugar	27 million tons
Meat	30 million tons
Cotton	8 million tons
Wool	2 million tons

ally renewable material and can live well even after the last drop of oil has been pumped, the last ton of steel fabricated, and the last ton of coal mined. This fact arises from increasing industrialization based on wood.

In gross tonnage, only coal is produced in greater volume than wood. If all the foodstuffs in the above table be added together they amount to 777 million tons. However, this table omits a very important product of the soil, grass, which is represented in a secondary way in an undetermined portion of the figures for milk, meat, and wool. There is probably no reasonably accurate way of estimating the magnitude of grass utilization. That it is large may be surmised by

TABLE 2.—WORLD WOOD CONSUMPTION AND TRADE
(Million m^3)

	Consumption	*Trade*
Fuel	800	—
Structural uses (lumber, squared timbers)	450	56.0
Paper	100	60.1
Rayon and staple fiber	5	
Railway ties	30	2.5
Mine props	30	6.6
Other uses	85	1.4

material. Even then, 1.2 million tons of fiber are produced annually from wood, a respectable figure against 2 million tons of wool, 8 million tons of cotton, and a comparatively unimportant 60,000 tons of silk. The trend of recent years indicates a vast

Fig. 3. Sawmill at Pasadena, California

putting the figure for meat in terms of grass equivalent. Estimating a use of 20 pounds (approximately 9 kg.) of grass per pound (0.4536 kg.) of meat, 30 million tons of meat would represent 600 million tons of grass. It is probable that the total conversion of grass in one form or another approaches the magnitude of the use of wood. An estimate of the distribution of the world's wood consumption among its more important uses is shown in Table 2.

Most of these uses employ wood as wood for final use. Only a few, paper, rayon, and fiber, and some under "other uses," use wood as an industrial raw

increase in fiber derived from wood that will come the more rapidly because of great improvement in the quality of fiber from wood that is in the making

Wood as fuel.—The largest use of wood, fuel, is the most primitive, the most wasteful, and among the most important. Over vast regions, where coal is either unavailable or costly, wood constitutes the only fuel and makes life possible. Even in regions of wood scarcity the population depends upon wood or charcoal for winter warmth and the preparation

of food. Indeed, there are many examples of complete denudation of forested lands in Africa and Asia through generations of harvesting for fuel alone.

Pressing as is the use of wood for fuel, its use thus is a wasteful business. In the manufacture of charcoal, a fifth of the weight of the wood is lost as gases and only at best a third of its weight recovered as charcoal fuel. If wood distillation for charcoal is carried out in modern equipment and the by-products recovered, the process is more efficient but still a wasteful conversion of potentially valuable material.

The relative efficiency of heat recovery in the various methods of burning wood fuel might be listed thus:

1) Open fire (lowest)
2) Crude open fireplaces
3) Fireplace with gas circulating accessories
4) Ordinary stove with controlled drafts
5) Highly developed stove and furnace

Fortunately, wood serves well in any of the listed wood-burning equipment, from the open fire at the squatting place of the aborigine, to the automatic, continous feed, gas-consuming furnace of the most highly industrialized community. It is to be expected that the development of industrial uses for wood will tend to decrease its wasteful use for fuel and increase more efficient consumption.

Wood as structural material.—The use of wood for structural purposes is second in importance but it can hardly be expected that any statistical statement could include all the myriad forms that such use takes. In the rude "jacal" of the Mexican Indian, the kraal of the African, the elaborate city home of the Swede, in factory, bridge, and boat, wood has played a leading role. It has carried loads, transported foods, framed and sheathed buildings, and sheltered the builder. It carries the millions of miles of communication and electric wires and supports the wharves that charge and discharge ocean-borne commerce. All these functions and more are fulfilled by wood, as a crude material, for the most part crudely and lavishly used.

In general, the use of wood for structural purposes has until recently been wasteful, due largely to the fact that standard factors of strength and working stresses have been either available or, when available, unapplied. This has led to the use of larger members than were required to carry a specific load, overdesign for strength and stiffness, or, more generally, practically no engineering design at all but a mere use of wood as the most easily available material and one that would do the job. Fortunately, the sheer versatility, workability, and relative abundance of wood in many countries have combined to make it the universally used housing material that it is.

The use of wood as railway ties, while relatively small in volume, is of tremendous importance. It is hard to conceive of the railway transportation systems having reached into all corners of the globe except upon a wood base. Only where wood was very scarce and expensive have other materials replaced it for sleepers and nowhere are other materials used by preference.

Similar remarks apply to the use of wood in the mines. Perhaps other materials could be used for the job, but this rarely occurs.

New Developments in Wood Utilization

This age-old engineering material, wood, has thus delivered immeasurably valuable service to man and continues to do so. However, from two points of view, the uses of wood are changing rapidly and will probably continue to change. First, new advances in general fields of technology have application to the manner in which wood is used. In general, they have the effect of broadening the scope of quality of wood that can be used for a specific purpose. Second, the use of wood and, thus, the harvesting methods have become a most important tool with which to control and perpetuate the resource itself.

Lumber—improvements in manufacture and application.—There seems to be no question that, generally, wood for structural material will continue to be the most important single product of the forest as far as value is concerned. While it is true that in Canada and Scandinavia short forest rotations are being planned on an exclusive pulpwood basis, possibilities of such operations have definite economic limits. In most forest territory, lumber is the primary product; it must bear the major cost of forest management, of sawlog transportation, and primary manufacture.

In the past, with the exceptions noted, the lumber market has pretty well determined silvicultural practices. Thus, although no particular broad effort has been made to grow high quality lumber outside of Europe, the demand for such lumber and the prices brought by it have caused selective harvesting and culling to the eventual detriment of the productive capacity of the forest. The *growth* of lumber has been left too much to chance in most of the world. The essential problem in lumber is twofold: the application of modern technology to the broadening of the supply base, including species and qualities of trees not hitherto harvested for lumber; and maintaining and increasing consumer satisfaction in lumber even while broadening the base.

Forests do not grow all clear lumber. There are trees and parts of trees that can make only knotty lumber or can produce only short lengths of clear wood. The ideal forest management occurs when the harvest can take the whole growth in a balanced way, and use can be found in the whole crop. This ideal can rarely be reached, but diversification of the lumber harvest itself can go far toward its realization.

The waste of wood involved in growing, harvesting, and manufacturing lumber is truly appalling. When unused species and cull trees left in the forest; tops, limbs and breakage left in the harvest; and slabs, edgings, sawdust, and trimmings in lumber manufacture are all added together, less than one-third of the total volume of wood grown in the forest gets to market. The waste of material in production of pulp is not much different. It is upon this present waste pile that future conversion industries can be based, with resultant benefit to the forest in addition to increased production of useful goods.

Techniques of lumber manufacture and use are far advanced today compared with their status fifty years ago. Widespread use of controlled drying machinery has brought about orderly marketing of lumber dried to specified moisture content for specific uses. Air-drying procedures, useful in some climates, are better controlled. And both methods yield lumber today that

approaches standardized quality. New techniques of seasoning that make use of chemicals are being applied to many species that have been classed as refractory, unsuited for lumber manufacture. The same techniques are being applied to the seasoning of heavy timbers, with large reduction in degrade and corresponding increases in consumer satisfaction.

There is room for great improvement in international trade practices in the fields of lumber grade and moisture content standardization. Uniform and satisfactory grades and standards for lumber of whatever origin should go far toward eliminating existing prejudices and difficulties in marketing. Likewise, uniform international standards of strength are needed in order that lumber specifications may be internationally applicable.

An interesting new development in seasoning practices is represented in the use of solvents to remove water. There have been numerous approaches to this problem in the past, generally unsuccessful. It now appears that commercial application of certain new principles may be practical in such a way that the extractive materials dissolved from the wood by the solvent go far toward paying the cost of the process, while a higher grade lumber is being produced. Preliminary indications are that the process may have rather wide applicability especially to certain hardwoods notoriously difficult to dry. By-products will vary from species to species, but oils, fats, resins, and certain sugars may be expected to be produced.

Rapid drying procedures are being developed that depend upon the generation of heat inside the wood by high-frequency electric currents. Where very cheap electric power is available, this field may become important.

Improved durability.—Wet wood decays more rapidly than dry wood—a very good reason for seasoning wood. But in many uses wood must be wet and still able to resist the action of decay organisms. Some woods are very durable under damp conditions, but the most abundant ones are not. Therefore, they are impregnated with toxic chemicals that render them more or less immune to attack by fungi and insects.

The oldest and still most widely used preservative is coal tar creosote, which is reasonably economical and quite effective. For example, properly creosoted railway ties now last 30-40 years, whereas 10 years is considered a good life term for uncreosoted ties. Proper treatment, applied to timbers, posts, piling, and supports that must be installed in damp conditions ensures a long life.

However, for many uses where durability is required creosote is unsatisfactory because of odor, color, and general smeariness. More satisfactory treatments have been devised using various chemicals that leave the wood clean, odorless, and capable of being painted. It may be confidently expected that, as chemical science progresses, new chemical combinations will be developed that will be better than those already in wide use. There is also promise that a generalized theory of toxicity of organic compounds will lead to the synthesis of materials specifically designed for wood protection. In short, although the task of protecting wood against insects and decay has been well done, larger improvements may still be expected, both in quality of service and cheaper treatments.

Fireproofing.—Wood is combustible and, in dense centers of population, has lost much of its inherent advantage as a structural material because of this property. Modern techniques of impregnating wood with fireproofing chemicals have created substantially fireproof wood. The processes are still costly, however, and cannot produce cheap fireproofed wood for general use. They can and do make available fireproof wood for use in critical situations or points of high fire danger.

Strangely, although wood and other materials are fireproofed, successful treatments have been mostly accomplished by empirical experimentation. No satisfactory theoretical explanation of the ability of certain chemicals to prevent combustion has yet been developed. Undoubtedly this will be done and, when accomplished, will lead to a sure scientific basis for fireproofing. In the meantime, lumber can be fireproofed, and certain forms of modified wood to be described later, are substantially fire resistant.

Prevention of shrinking and swelling.—Although a considerable degree of stability is imparted to wood by proper drying, insofar as taking on and giving off moisture is concerned, generally it still shrinks and swells as relatively humidity changes. This property varies widely among species and within species according to growth rate and other variables. This may lead to warping, cupping, or splitting of wood, and various other manifestations that militate against fully satisfactory use. An important new development bids fair to furnish a cheap and satisfactory means of greatly reducing this tendency. Fortunately, the treatment is simple—merely heating the wood to rather high temperatures short of charring, under determined conditions of moisture content. Under these conditions, reductions of 40 percent in shrinking and swelling are obtained, which greatly improves the serviceability of wood for many purposes.

Laminated timbers.—These treatments designed to improve the serviceability of wood are generally applicable to lumber and timbers, but the task of utilizing the entire forest crop calls for means that will use short pieces—and small pieces that may be cut from boards of such low grade as to be unsalable as lumber. A great impetus has been given this field by the gradual exhaustion of virgin timber capable of yielding large members, and the necessity for replacing these large members by built-up pieces. The field itself is capable of exercising much influence on harvesting practices by permitting the profitable cutting of low-grade trees and recovery of their lumber yield in small pieces.

It should be pointed out that the development of techniques for laminating boards, and gluing of small pieces or gluing them by scarf joints, continuous edge gluing and the like, is comparatively recent, and is expanding rapidly as new and more satisfactory glues and gluing methods are available.

There are actually distinct advantages in built-up members over sawn timbers. Boards can be satisfactorily and thoroughly seasoned with less damage than can timbers. Hence, the gluing-up process offers a ready means of producing large preseasoned timbers that are stable and free from defect. This distinctly sharpens engineering design because the properties of

the fabricated piece can be more accurately known and, in fact, these heavy pieces can be "tailor made" for particular jobs.

The construction of laminated arches from wood derives simply from the construction of laminated timbers. The flexibility of single boards, either sawn whole or built up, permits them to be bent successively and clamped to a form as a glued assembly. As the glue sets, the boards are firmly joined in a unit, the size and form of which can be predetermined and carefully engineered for the specific function.

The easy workability of wood, the comparatively small investments required for fabricating equipment, and especially the adaptability and utility of the fabricated material make lamination of timbers, arches, trusses, and other structural units a promising outlet for a great deal of material not hitherto usable as lumber. The introduction of thermosetting waterproof resin glues, combined with new methods of applying heat rapidly and economically to the glued joint, make possible laminated materials suitable for exterior use or for such trying uses as boat keels and ribs, large numbers of which have been manufactured during the war. The next great improvements may be expected in the production of quick-setting cold resin glues that will be waterproof, thus eliminating the necessity for heat in joining and greatly cheapening the process.

Durable plywood.—The new waterproof resin glues have also revolutionized the plywood industry, turning it from the manufacture of a material strictly for interior or temporary use to the manufacture of a thoroughly weather-resistant material of well nigh universal applicability. Weatherproof plywood, glued to supporting members, contributes a large share of strength and stiffness to the unit. Such units are so strong that weight can be reduced to a minimum and they can be fashioned easily in mass production for specific purposes. This has brought about the use of plywood as a construction material par excellence, and its use in this field is rapidly expanding.

Supplies of veneer-quality timber are limited in the Northern Hemisphere, especially as regards the clear, virgin softwoods that are contributing too heavily to the volume of cheap plywood being manufactured. Trends may be expected in the following directions: 1) pruning for the production of veneer logs; 2) new methods of producing satisfactory veneer from small logs; 3) utilization of tropical hardwoods for plywood.

Techniques for bending and molding plywood are well developed so that an enormous variety of forms and shapes can be easily produced. Also, the use of new special wood and paper products as well as metals for facing plywood may be expected to give a large variety of new and serviceable materials based on veneer and resin glues.

Wood a standardized engineering material.—These new forms of fabricated wood, capable of accurate engineering design and with accurately predictable properties, are rapidly lifting wood to the level of a standardized and preferred engineering material. A very old handicap under which wood suffered in heavy construction, the difficulty of joining large timbers as a strong joint, has been overcome in recent years by the development of a large number of special connectors made of metal. With these connectors a wide variety of joints can be satisfactorily built, the wood being factory machined for the connectors, and assembly taking place on the job. Large trusses and trussed arches are being erected with entire satisfaction and distinct advantages in many applications. The system lends itself well, also, to prefabrication of smaller members for assembly into structures at the building site.

The trends in fabrication and in joining wood have been combined with intensive research in the mechanical properties of wood to change its status radically within the past 25 years. It takes its place now as a precision engineering material with inherent natural advantages that ensure its permanent status. Continued research in new methods of use and further refining of its engineering properties should further raise its level of adaptability.

Most of these newer trends in wood utilization require, or will be better met by, wood of good quality, clear lumber, or lumber of comparatively high grade. Veneer manufacture requires clear wood for good yield and efficiency. The engineering advantages of wood are functions of its own peculiar structure and clear, straight grained wood apparently will always command a premium.

New industries from waste.—It must be repeated, however, that the process of growing such wood is almost always accompanied by the growing of variable proportions of lower grade trees; tops and limbs must be produced, and lumber manufacture inevitably produces a good proportion of offal. There is a school of thought that looks at the forest as merely a future producer of wood to be ground up, pressed into "synthetic lumber" or plastics to the final exclusion of structural material as a principal product. There is nothing yet technically possible that warrants such a point of view. Disintegrated wood, reassembled in any form, lacks the strength and the oriented strength of normal wood and is not as adaptable or workable in the myriad uses of wood.

The costs of so-called "synthetic boards" are mostly manufacturing costs and they can return little for the cost of growing trees. Forestry will, in all probability, continue to receive the major share of its returns from good lumber and veneer, posts, piling, and the like. While industries may be based on the by-product wood, the price of the raw material for these industries must in all probability be low in order that the industries may survive.

Modified Wood

"Impreg" and "compreg".—The inherent valuable properties of natural wood, its high strength-weight ratio, great strength along the grain, resilience, and ease of fabrication, have been vitiated to some extent by its tendency to shrink and swell under variable moisture conditions. The ideal material for most uses might be visualized as combining high thermal stability and imperviousness to moisture with the strength of steel, the hardness of diamond, and ease of working. There has never been any such material. Most materials are lacking in some property and those combining most desirable properties are rare and expensive.

For generations efforts have been directed toward

Fig. 4. Selective cutting in Ponderosa pine, Pinus ponderosa *Laws, stand in Oregon*

developing in wood those properties it lacked while preserving its inherent advantages. Obviously, because of the abundance of wood and its broad distribution, the accomplishment of this task in an economical manner would be expected to broaden its applicability in those fields now occupied by it, and to render it serviceable in fields for which it has not been suitable.

In recent years most attention has been given to overcoming or reducing the property of wood to take on and give off water as relative humidity changes. Doubtless, this is the most troublesome property of wood and one that is widely variable among species, within a single species, and even with a single piece of wood. The peculiar structure of a log, the way a tree grows, is responsible for the fact that the greatest shrinking and swelling takes place in a direction tangential to the original round log, the next greatest in a direction radial in the original log, and least of all longitudinally. These facts introduce many complicating factors in sawing lumber, kiln drying or air-seasoning, grading, selection for use, and fabrication. Lack of dimensional stability under changing moisture conditions is probably the most undesirable property of wood.

The wood fiber itself is a hygroscopic material, that is, it has a great affinity for water. The cellulose component of the fiber has tremendous affinity for water and responds rapidly to even relatively minor moisture changes, altering the size and shape of the fiber and thus the piece of wood itself.

Two fields of purely fundamental research have contributed heavily to advances toward solution of the problem thus posed. Primarily, the knowledge of the ultimate chemical composition of wood developed during the past 50 years has brought about excellent understanding of the chemical groupings responsible for the properties of the internal surfaces of wood. Secondarily, but of tremendous importance, the newer field of surface or colloid chemistry has given understanding of the physical nature of the relationships existing between internal wood surfaces and liquids, especially water.

If it be considered that the submicroscopic internal surface existing in a cubic inch (16 cm^3) of wood amounts to about an acre and a half (6,000 m^2) and that all this surface is capable of physically binding a layer of water several molecules in thickness, the complexity of the problem becomes evident. Most of the swelling that takes place when wood absorbs water is internal, but the net result in changed external dimensions is the more disturbing.

"Impreg".—At first glance, the obvious solution is merely to plug the very small pores and open spaces in wood with materials that are not wetted by water. This has been accomplished by the use of waxy and paraffin-like materials applied in various ways, either impregnated in molten condition under pressure or impregnated under pressure or by diffusion while in solution in an appropriate solvent, later evaporated. The net result is always about the same. A slowing down of the rate of swelling is obtained, but the final product is the same as though no water-resistant impregnant were present.

This result has been shown to arise from two facts: the impregnating substances, being always large molecules, could not possibly enter the submicroscopic spaces between the "fibrils" or very small particles of cellulose composing wood fiber; and the chemical nature of the internal surfaces, their affinity for water, was not altered by the treatments. The action of the impregnants was a purely physical one, slowing but not stopping the absorption of water.

Considerable advancement in this field became possible with the development of synthetic resins of the phenol-formaldehyde or "Bakelite" type. The components of the resin, phenol and formaldehyde, small molecules, are introduced into the wood in solution and then formed into resin by heating the impregnated wood. The small size of the molecules permits complete permeation of the wood structure and the chemicals themselves react with the wood internal surfaces, thus decreasing their affinity for water. Using this process, the swelling and shrinking of wood is reduced to 30 percent of normal with improvement in compressive strength and hardness but lowered resistance to impact. Electrical resistance is increased because the wood remains drier under all conditions. Resistance to decay and termites is greatly enhanced.

In general, the applicability of the process is limited to woods that are readily permeable to liquids and the cost is considerable because of the relatively high cost of the resin-forming components employed. The broadly increasing uses of such resins are causing intensive search for cheaper ones, a source for which may well be within the wood itself. The process has been much used in Europe and may be expected to become more widely employed.

"Compreg".—A modification or extension of the impregnation process just described yields a product with vastly improved properties. Impregnation is carried out as above, the objective being to complete penetration of the wood substance with the resin-forming chemicals and also chemical reaction with the water binding elements of the internal cell wall surfaces. This latter, accomplished by heat, is accompanied by plasticizing of the wood which makes it compressible under pressures of 1,000 pounds per square inch (70.3 kg. per cm^2). Under these conditions, almost any species of wood can be compressed to a specific gravity of 1.3 to 1.4 and about one-third its original thickness. Practically all the softer woods can be compressed to half their original thickness by pressures as low as 250 pounds per square inch (17.6 kg. per cm^2). This makes possible the compression of face veneers and their simultaneous assembly with untreated slices, or with treated and pre-treated cores with but slight compression of the cores. Such products will have the desirable surface properties of "compreg," the common designation of the product, combined with lightness and cheapness in the more bulky core.

"Compreg" takes a high degree of polish and, because it is the same material throughout, scratches or scars can be easily removed by merely sanding or buffing.

Water absorption by "compreg" is so low as to be negligible for practically all uses and its dimensional stability is all that could be desired. Its strength is proportional to the degree to which it is compressed; if to a third of its original volume, general strength properties are trebled and approach those of a mild steel. Strength-weight ratios are of the order of light metal alloys. Brittleness is again increased, a property not particularly important in the uses to which the material will be put.

This new, strong, durable, and stable material can be machined easily with metal-working tools. Therefore, techniques have been developed in which the final object of manufacture is roughed out with wood-working tools before compression and is then formed in a mold under appropriate pressure. Wood, therefore, becomes a molding plastic in a way, but its inherent valuable oriented strength properties are preserved.

It is of great importance that satisfactory "compreg" can be made from woods of any original density, very light or very heavy. Only highly resinous woods and woods relatively impermeable to liquids are excluded.

"Uralloy".—Other materials than phenol-formaldehyde resins are available with which to improve wood properties but, to date, none have shown equal properties. Some are more economical, for example, the urea-formaldehyde treatments, but do not yield as good a product. The field of other impregnants is being diligently explored and, doubtless, the chemist will turn up better materials. It is even probable that lignin, itself derived from wood, may become the source of improved resins for impregnation since recent work shows it to be a good source of certain resin-forming chemicals.

"Staypak".—The cheapest method of increasing the strength and dimensional stability of weak woods of low density appears to be one that takes advantage of the fact that wood is plastic to some degree and compressible when heated to moderately high temperatures under a certain controlled moisture content. The process is said to be rapid and economical, consisting of merely heating the piece to proper temperature and compressing to the desired density. Strength of the compressed wood is generally proportional to the density, and ultimate shrinking and swelling are about the same as that for a piece of wood of the same size, but the rate is very greatly decreased. This fact makes the product suitable for many uses where humidity is variable but resistance to immersion in water is not necessary.

All these new processes seem to offer opportunities for the utilization of tropical species whose properties are such that they have not hitherto entered world markets.

It has long been apparent that the permeability of wood to gases offers an excellent opportunity of obtaining quick and complete penetration with reactive materials. Unfortunately, few of the materials hitherto found most useful are vapors at satisfactorily low temperatures. Progress is being made, however, and recent successful treatment of wood with vapors of acetic anhydride to block the chemical groups that are responsible for water absorption has shown promise.

In short, it appears that considerable progress has been made in modifying wood to eliminate or reduce one of its least desirable properties, shrinking and swelling, while enhancing its beauty and durability. The field is a young one, susceptible to much more productive exploration, and one that will have to be

re-explored as progress is made in chemical fields that develop new impregnating materials.

Converted Wood

When wood is used in its original form or as some form of impregnated and compressed wood, its value rests upon its physical and mechanical properties. But this versatile material is also an interesting and important source of chemical goods and must therefore be regarded as a raw material of chemical engineering.

Destructive distillation of wood.—Certainly the oldest and probably the most widespread use of wood as a crude material for chemical engineering is the process of dry distillation, principally for the manufacture of charcoal. The world over, transformation of bulky wood to light-weight charcoal, concentrating fuel value in relatively pure carbon, has been a principal source of domestic fuel. Since charcoal is easy to transport and burns with an easily controllable, practically smokeless fire, its use is well nigh universal, especially in those countries not possessed of developed coal or oil supplies that have been made available for domestic consumption. A prime advantage of charcoal as fuel has been the primitive nature of the arrangements necessary for its use. The simplest brazier of charcoal may suffice to cook a meal or warm the interior of a hut when no other heating apparatus is possible.

Thus, from earliest times, charcoal burning has been a well developed art and has followed man whenever he has had forests. Charcoal has been the basis for domestic heat, but it has also contributed to the advanced use of metals. Just when and where iron was first separated from its ores by the use of charcoal is lost in the dim past, but the production of the highest qualities of steel for special uses and nonferrous alloys of specified carbon content and purity still depend to a large extent upon charcoal. In many countries of high population density in proportion to forest wealth and low industrialization, the continued impact of charcoal burning upon the limited forest has reduced the forest to a very low level of productivity. In other countries that are relatively rich in forests and well industrialized, charcoal manufacture, or rather wood distillation, has been a good tool of forest management, since the industry can and does use tops and limbs as well as low-grade cull wood. There is no question that, if the economic situation is satisfactory, wood distillation is an attractive component of a balanced scheme of forest products utilization.

In general, distillation for the production of charcoal alone takes place only under two sets of conditions: 1) limited fuel supplies and demands, thus a semitropical climate with a low industrial development; 2) production of charcoal for industrial or domestic use on a highly developed technical scale with full recovery of distillation by-products.

In the first case, distillation is a crude business, carried out by piling wood under turf or mud in such a way as to burn it with limited access of air, allowing the products of distillation to escape as part of the smoke.

In the second case, distillation is accomplished in closed retorts connected with condensing and refining apparatus to recover the valuable chemicals contained in the distillate. These are combustible gases, methanol (wood alcohol), acetic acid, and tars, along with minor constituents over one hundred in number. Since most of the tar components occur in very small percentages, their separation on a commercial scale has rarely been attempted. The gases are generally used in heating the wood. Formerly, the commercial demand for methanol and acetic acid, either for use as such or for manufacture of acetone, was an important factor in maintaining a vigorous wood distillation industry, especially in Europe and America. More modern and cheaper processes for the production of synthetic methanol and acetic acid, as well as acetone and acetic acid by fermentation, have thrown the burden of costs upon charcoal alone. Thus, only a few of those plants best equipped for complete recovery and with cheap and abundant wood supplies have been able to maintain themselves.

From a strictly scientific point of view, wood distillation is a wasteful procedure. Roughly, the final yield from hardwoods consists of about 38 percent charcoal, 42 percent volatile condensible material, and 20 percent gases where the distillation is the ordinary technical type. From softwoods containing resins, yields are different and other products of turpentine character are obtained. Clearly only the most efficient recovery and use of the condensate can be profitable in a highly industrial economy. Charcoal must compete with cheaper sources of industrial carbon in metallurgy and command a premium only where purity is a requisite or where high gas absorptive capacity is necessary. Both fields are limited in the tonnage they can normally absorb.

Having regard for the potential values in wood that can be obtained by more refined chemical procedures, it does not seem likely that the dry distillation of wood as now carried out, can long persist as a part of industrial wood technology except under most favorable conditions of wood supply and market for charcoal. No heavy expansion of the existing industry can be foreseen. However, it should be pointed out that research could very easily bring about a major transformation in this old industry and put it back on a computing basis.

It has been found, for example, that vacuum distillation yields products of entirely different nature that have not yet been subjected to critical examination. Furthermore, distillation under the influence of various catalysts offers a field of exploration that is attractive, especially when combined with high-frequency radio heating so as to achieve closer thermal control during distillation. It is to be hoped that such improvements will be forthcoming as will make wood distillation economically possible because no other process can yet absorb such a wide range of species and qualities of wood.

Pulp and paper.—The manufacture of wood pulp and paper products, in contrast with wood distillation for charcoal manufacture, is comparatively limited in its extent to industrialized countries. It is further limited in the nature of the woods that it can utilize but, in countries with large sources of suitable wood and good paper markets, it has become an important economic factor.

It is the base for most paper, thousands of products of everyday use from pulp or paper, and a rapidly

growing textile and fiber industry. It furnishes the raw material for the many new chemical industries developing around wood cellulose as a raw material. It has grown by leaps and bounds in the last 25 years and, as new industrial uses for paper appear, seems to have no visible limit of magnitude. While only 22 percent as much wood is now used for paper as for structural purposes, 60 percent of the product enters international trade. If a nation's use of paper may be taken as a rough measure of its standard of living, the world will need enormously increased volumes of wood pulp products, as general living standards improve. These must come from the forests, and the forests must increase in their capacity to satisfy world demands.

Perhaps because most present wood pulping processes were developed in predominantly coniferous regions, they have been best adapted to coniferous trees. Roughly, the principal pulping processes are: 1) acid processes, exemplified by the sulphite process, principally applied to spruces, firs, and hemlocks; 2) alkaline processes, exemplified by the "Kraft" or sulphate process, principally applied hitherto to the pines; also the "soda" process, applicable to hardwoods; 3) the "semichemical" process, originally applied to hardwoods but apparently quite broadly applicable; and 4) the mechanical or "groundwood" process, generally applied to soft woods of light color.

Acid and alkaline processes have in common the fact that they are intended to dissolve the lignin component of wood while leaving the cellulose in a more or less purified condition in the form of a fiber. They are applied under widely variable conditions in accordance with the desire to produce wood pulps that can meet an enormous variety of requirements. These may cover the entire range from nearly pure alphacellulose for rayon manufacture, to a crude, unbleached pulp for manufacture of a fiber board, from a high-grade "bond" paper to a coarse "butcher's wrapper." Strength requirements are as widely variable. There occurs, therefore, a highly complex interplay of wood species, pulping methods, and paper-making technology in the production of the enormous variety of pulp and paper products.

The development of the two other processes, semichemical and groundwood, arose primarily from the cost and low yield of the chemical process. Generally, the chemical processes yield 50 percent or less of the weight of the wood as pulp.

Since the cellulose and hemicellulose fractions together make up about 75 percent of the wood fiber, it seemed logical to preserve the fiber structure by disintegrating the wood by less violent means than usually employed. In the semichemical processes this is accomplished by mildly cooking wood chips in an appropriate softening medium and then breaking the chips into fibers by mechanical means. In the straight mechanical processes, the billets of wood are held against rapidly revolving stones and are literally eroded into fibers. Both processes give high yields of pulp suitable for many purposes where best color and high strength are not required.

The semichemical processes in particular are capable of much wider application on a broader base of wood species and quality. These processes, in some forms, use spent liquor from sulphite or sulphate mills as softening agents and are thus admirably suited for incorporation into diversified utilization organizations. Since they are generally much less critical of wood species and quality than the strictly chemical processes, they can employ woods and sawmill waste, the refuse from lumber and chemical pulp manufacture.

The mild chemical action to which semichemical pulps have been subjected results in the presence of a high percentage of pure alphacellulose that would be degraded by the more severe treatment of the standard chemical methods. Processes have been designed to remove the hemicelluloses and traces of lignin from these pulps, with the production of remarkably high yields of alphacellulose in forms suitable for textile or sheet viscose manufacture, or incorporation into a broad and increasing variety of cellulose plastics. High-grade cellulose for chemical manufacture, derived from these processes, may be expected to compete favorably with similar products based on chemical wood pulp or cotton.

The acid or sulphite pulp process has generally been applied to woods with long, strong fibers and light color, or easily bleached. Since good penetration of an acid cooking liquor into the chips is absolutely necessary, pitchy or knotty wood cannot be used. Hardwoods have not given good results, nor have any but young pines containing little or no heartwood been usable. In some countries, a system of forestry is possible that aims at the continuous production of wood suitable for sulphite pulp and the integration of sawmills with such production. Sulphite pulp is generally light in color and strong, therefore useful in combination with short-fibered pulps. Need for it will probably continue, but a shrinkage of the industry in North America is anticipated as the supply of sulphite wood lessens.

This lost volume of sulphite pulp will be more than compensated by expansion of the sulphate pulping industry, based on new procedures that not only make the process applicable to many previously unused hardwoods; these new procedures can even pulp mixtures of hard and softwoods and are beginning to approach the time when "run-of-the-woods" billets can be pulped satisfactorily without regard for species.

A radically new pulping procedure developed in the United States of America gives promise both of increased yields of pulp and new industries based on wood. The process, called the "holocellulose process," effects a clean separation between the lignin and the carbohydrate components by very mild procedure. The carbohydrate mixture, about two-thirds cellulose and one-third hemicellulose, may be used as pulp or further fractionated for the separation of the hemicellulose fraction and the production of high purity chemical cellulose. These hemicelluloses offer industrial possibilities along many lines still poorly explored. In fact, industry has never had these materials available in clean forms, susceptible to the further treatments which they are capable of receiving with profit.

To the myriad forms of paper already in use, was added a new one, potentially capable of absorbing unimaginable quantities of pulp. Paper, impregnated with synthetic resin, laminated and pressed under heat, becomes a hard, tough, strong material new to industry but already filling many jobs. By research, the strength of the product has been greatly increased; by controlling the manner of laminating, strength properties can be built into the finished board according to need, a property which distinguishes "papreg" from most artificial boards. The new

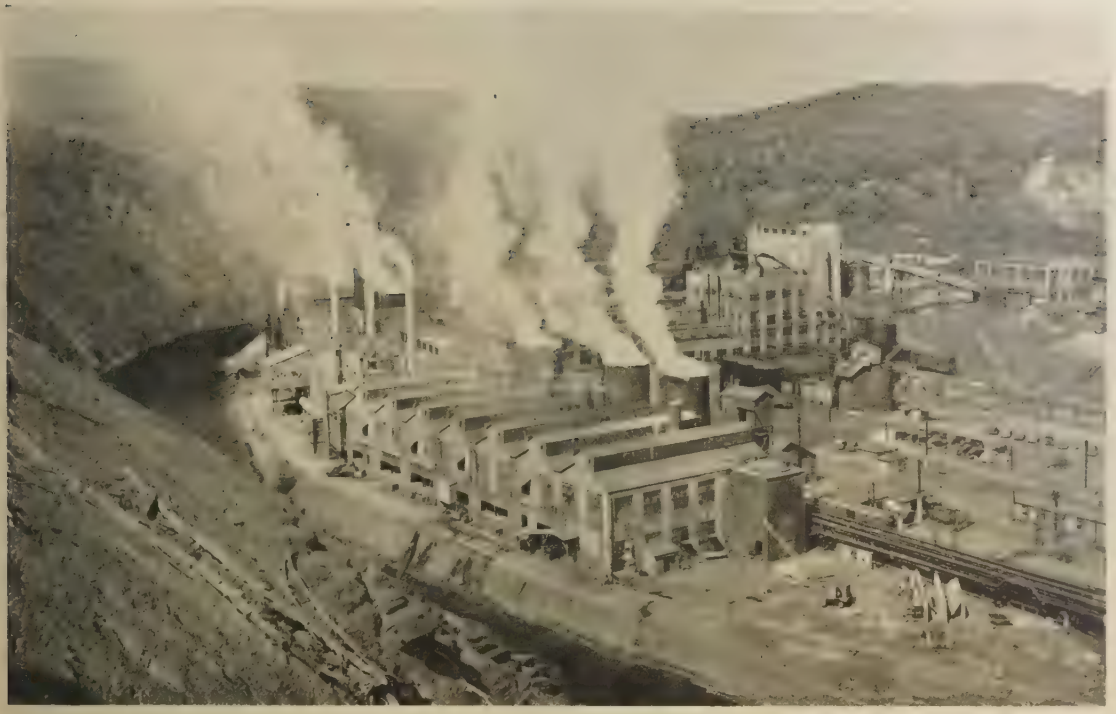

Fig. 5. Paper mill at Covington, Virginia

material is used to form the wearing faces on light cores, thus giving a hard finish and requisite stiffness to lightweight "sandwiches" that seem to have quite broad applicability. It can be bonded to metals, or combined with lacquer finishes. In brief, here is a new material with strength, durability, and adaptability that can be easily molded to shape and worked in many forms. Paper has become a structural material.

Increasing application of paper to structural fields may be reflected in increased need for high-strength pulps. Strong sulphite and Kraft pulps will probably meet that need, but the newer processes may be expected to develop employable strong pulps.

Complete recovery of by-products of pulping is certain to be widespread eventually as increasing price competition compels the recovery of all possible profits. The sulphite industry in Europe already recovers the sugar from its waste liquors as alcohol or feeding yeast. Some lignin recovery is also accomplished both in Europe and America, but it is unthinkable that the inherent values in lignin, 25 percent of the weight of the wood pulped, should continue to pollute streams and harbors. Shifting to magnesia base cooking liquor, replacing lime bases, and thus making possible complete chemical recovery, will be an important trend. This procedure will do several things: 1) eliminate pollution, 2) recover the fuel value of lignin, 3) simplify recovery of by-product sugar.

The sulphite industry is characterized by full recovery of the chemicals used, and of the fuel value of the lignin. However, the American industry recovers only a fraction of the by-product resins, fats, and volatile oils that are recovered by the North European industry. No sugar recovery is possible in this industry but, as values are developed from lignin, it may be anticipated that sulphate lignin will be isolated and other fuels substituted for it in plant operation.

In addition to laminated, resin impregnated paper for structural purposes, recent excellent progress has been made in the utilization of lignin from the alkaline pulping processes as an impregnating material. Lignin from the soda or sulphate process is recovered, impregnated into either the pulp or paper, and the paper laminated and hot pressed to give a very hard and strong board which has considerably higher impact values than the corresponding "papreg." Considerable progress has been made also in conversion of sulphite lignin to valuable materials.

As competition increases in the pulp industry, it may be expected that all possible sources of additional profits from by-products will be explored.

The numerous variations in form and character exhibited by various types of "fiber boards" and insulating materials produced from wood in some form or other attest again the versatility of the basic material.

Wood hydrolosis.—Pulping processes are primarily hydrolytic processes: that is, water, under the influence of acid or alkalies, splits wood into its chemical components. One hundred and twenty-five years ago it was found that if the hydrolytic processes were carried sufficiently far, the cellulose and hemicellulose fractions were broken down into sugars. As the composition of the cellulose and hemicellulose became clarified, the nature of the sugars obtained from them also became clear. Generally speaking, these sugars are mixtures of hexoses, exemplified by glucose, and pentoses, exemplified by xylose. The proportion in which

these sugars occur as decomposition products of wood varies considerably between hardwoods and softwoods, the former containing a larger proportion of the pentose or five-carbon sugars that are not ordinarily fermentable to alcohol by yeast.

Although the discovery of the formation of sugars from wood was made so early, it is only comparatively recently that any great commercial success has attended this discovery. In general, two lines of industrial development have been followed: very strong acids have been used to decompose the cellulose material, followed by dilution and fermentation, or dilute mineral acids have been used. Each form of process has had its advocates and industrial trial. The aim in all cases is to produce a crude sugar solution of usable concentration and of a character fermentable to industrial chemicals. The rapid development of industrial fermentology within recent years has had considerable importance in the possible production of a very cheap sugar solution from wood because, instead of the recovery of edible sugars, the objective is the conversion of the crude material to further derivatives.

Three general lines of fermentation development are currently under way and may be expected to continue. The first and most interesting during the war was the production of industrial alcohol from the hexose sugars by fermentation with ordinary yeast. After separation of the alcohol, the remaining pentose sugars may be subjected to any one of a number of fermentations that give rise to a series of industrial chemicals, or used as a medium for the growing of feeding yeast, a potentially valuable high-protein component of animal foods. A second important line of development follows the procedure of converting all the sugar yield to feeding yeast or other organisms that convert sugar to protein. A third line makes use of various double fermentations for the production of other materials than alcohol. There is no visible limit to the variety of chemicals possible by these procedures.

The most successful process thus far appears to have been that developed by Scholler in Germany prior to the war, greatly modified and improved by U. S. chemists during the war. Under present U. S. techniques it appears that German plant installation costs will have been radically reduced and efficiency of operation greatly increased without sacrificing yield, which remains in the neighborhood of 1,100 pounds (approximately 500 kg.) of total sugar per ton of dry softwood waste. The process yields from 500 to 600 pounds (approximately 225 to 275 kg.) of dry lignin as a by-product, which for the present will serve as fuel in the industry. However, research in progress gives every promise of developing lignin into a source of industrial chemicals of importance. It is of considerable significance that among the chemicals that have been produced from lignin, are found the very phenols that form such important ingredients of improved wood and paper products. Especially if cheap electric power is available, it is anticipated that the transformation of lignin into chemicals will become an integral part of forest products industry and that products derivable from lignin will be in a large degree incorporated into subsequent manufacture of wood materials.

The profitable conversion of lignin to chemical or other goods may be said to constitute the key to the entire problem of utilization of wood waste. In simple arithmetic terms, for example, 10 pounds (approximately 4.5 kg.)of lignin would be produced for each U. S. gallon (3.7853 liters) of alcohol; thus a return of U. S. $0.01 per pound (0.4536 kg.) on lignin would permit $0.10 a gallon to be taken off the price of alcohol. Demand for cheap alcohol should develop far beyond present supply possibilities; other cheap products of fermentation offer similar possibilities.

The possible utilization of the sugar produced for a diversified line of fermentation products, of methyl alcohol for formaldehyde, of lignin for phenols, and the use of these in the fabrication of wood and paper products, conjures up a picture of diversified chemical utilization of wood that offers tremendous industrial possibilities. This sort of waste utilization, geared to diversified use of wood as wood, constitutes diversified forest utilization, and a basis for a new concept of industrialization on wood.

The possibility of production of abundant and cheap sugar from the forest offers encouraging possibilities for achieving an integration of forestry and agriculture in a good deal of rugged territory with limited agricultural land that has not been possible in the past. For example, although summer grazing land may be sufficient for a reasonable livestock economy, the agricultural base for the production of winter feed may be insufficient to produce the feed necessary to carry livestock through a winter; therefore, the livestock base is often definitely limited. The production of protein feed from wood sugar seems to offer an opportunity to increase the protein feed supply in such territories and bring better balance between food supply and population. Likewise, increase in the protein component of tropical diets is a possibility.

There is another way of using these new products of the forest for the improvement of agriculture in the potential use of lignin, by-product of wood hydrolysis, as a humus former and soil builder. It is known that prior to the war Germany was using its lignin from the Scholler process as a soil improver. Work in progress in the United States of America looks toward the employment of lignin as a medium for the application of nitrogen and phosphorus in slowly available form, thus avoiding the usual heavy losses by leaching and employing lignin, a humus forming residue, as a carrier. These possibilities, if they can be successfully applied, may be of large significance to a great deal of rather poor agricultural territory in which forest acreage is predominant. Fortunately, in the production of yeast, the yield is equally high from hardwoods and from softwoods. This may prove to be of great significance to the tropics, critically short of protein food, abounding in hardwood forests.

Fuel.—The largest use for wood has been as fuel. Generally, however, its use for this purpose has been a crude one, and the true value of the material has rarely been obtained. In countries with thin population and abundant wood, this has not caused any violent distress; but in many regions with heavy populations, limited forests, and no other fuel, the result has been destruction of the forest itself. In industrialized countries, the cost of wood fuel in manpower required for preparation and transportation renders necessary improvements and economies in its use. As it becomes a more important chemical raw material, the worth of wood itself will make imperative refinement of its preparation and use as fuel.

Compared with coal, wood is a bulky fuel. Weight for weight, it has about half the thermal value of a

good coal. Yet, its cheapness, abundance, and cleanness have kept it in a leading position as ordinary fuel. As industrial efficiency has increased, improvements in the mechanisms employed for burning wood have followed. They have taken the same general form as those applied to coal; namely, the recovery of the heat from the total combustion of the volatile gases distilled during combustion. Numerous new forms of heating apparatus for wood, using continuous feed and gas combustion principles, have been developed and are in production.

Further improvements have been made in reduction of the bulk of wood waste from sawmills and manufacturing establishments, thus reducing storage space requirements and lowering transportation costs. These improvements have usually taken the form of compressing the waste into briquettes, blocks, or billets, and have provided very satisfactory fuels, although the cost has usually been too high for universal use.

Considerable thought has been given to the problem of reducing the labor required to prepare wood for use as fuel, at the same time preparing it in a form more adaptable to continuous feeding devices and adapting it to the more modern stoves and furnaces. Mechanization of the traditional sawing and splitting operations is the objective—simple, cheap, and effective means of reducing the log to material that can be mechanically handled in bulk.

Combined with these objectives, already rather well along toward realization, is the accomplishment of the use of wood as a source of power for the internal combustion engine. Those countries poor in petroleum are already using a great many motors powered with producer gas made from wood or charcoal. The expansion of this use may be expected because the low cost of the fuel itself will be the determining factor.

Producer gas from wood appears especially attractive as a source of power for relatively small power units on farms or in forest operations themselves. Their adaptability to stationary engines is clear and their use for self-propelling units has already made great strides. Bulkiness of the fuel seems to limit its use in the latter field to trucks and tractors as long as petroleum remains abundant, but, as the cost of gasoline rises, use of wood for motor fuel may be expected to increase, especially in those regions where wood is abundant and well distributed.

In general, producer gas from wood has merely been used in the existing types of internal combustion motors. Adequate study given to matters of compression ratios, rates of feed, and the like should lead to the development of motors especially adapted to wood fuel with greatly improved efficiency.

Either as wood, charcoal, or hydrocarbon fuel, wood can play an important role in the further expansion of the use of the internal combustion engine. Hydrocarbon fuel itself is a promising product of the chemical transformation of lignin and could be a valuable and important by-product of wood hydrolysis.

Thus, for domestic and industrial use, for stationary or mobile power units, the fuel value of wood offers a tremendous, renewable reserve when the temporary supplies of easily available petroleum shall have vanished forever.

Forest Utilization Research

It must be apparent that research in forest products utilization, a small segment of the total research effort, must continue at an accelerated pa[illegible] that the forests may contribute their share t[illegible] ing civilization and providing comforts to [illegible] This research should attack especially the enormous wastes of forests and lumber manufacture. Tremendous research effort toward better ways of doing things and better ways of living is perhaps the outstanding characteristic of twentieth century civilization. As long as civilization is progressing, researcl will be continued, or conversely, when reseach ends the development of civilization will also end. Research itself engenders more research. It is especially true that findings in even remote scientific fields make possible new developments in forest products utilization and make necessary further research efforts and industrial developments in that field.

For example, the invention and development of the internal combustion engine has brought about revolutionary changes in transportation. These changes have made imperative the development of new, light, strong forms of construction. These forms must be fashioned from materials that are available and cheap. It is not yet apparent whether they will be made mostly from light metal alloys or from wood. It is probable that the field will be divided between these materials according to suitable properties. In any case, the development of plywood, molded plywood products, and light laminated products has been a direct result of this demand for new types of structural goods.

It was not possible to make laminated wood prod-

Fig. 6. Chemical wood

ucts for outside use until chemical industry developed waterproof resin glues. With the development of such glues, their application to the age-old task of joining wood began, with the result that a great number of new applications of wood became apparent.

Thus, new requirements for new products in other fields bring about new industry and new developments in forest products uses, a process that will continue as long as civilization grows.

Economic Results of Industrialization Based on Wood

These new uses for wood make possible real industrialization on a wood base and thus widespread industrialization in territories formerly capable only of producing a crude raw lumber for distant industrial centers, usually founded on a mineral economy. If it is sociologically correct that a dispersion of the large industrial centers to smaller communities is desirable, industrialization based on wood offers a most promising possibility, principally because such industrialization need never terminate because of the exhaustion of the raw material base. No other industrial raw material offers at once the possibility of permanence and universal application that is offered by wood.

In too much of the world the limitation of production to crude goods tends to hold large populations in economic subjection to distant industrial centers. Without important exception, countries producing only crude goods have not developed high standards of living. Neither have high standards developed upon a strictly agricultural base. Industrialization based upon products of the soil can lead to the development of that widespread industrial civilization that seems to offer the greatest possibilities in human welfare. It appears that wood may offer a highly satisfactory base for such development.

The universality in application of wood may be the strongest argument for a wood base. In some form or other it can feed, shelter, clothe, and warm man.

Economic industrialization based on wood must take cognizance of two principles: 1) the raw material is the product of forest growth which is determined in large measure by the character of the harvest. Therefore, industrial use must be adjusted to the rate and character of forest growth in any particular place. Otherwise, there will follow unbalanced growth and unsatisfactory raw material supply for industry. 2) A second plan that must be followed is that of diversification of industry so as to use all the growth of the forest in the production of goods; distribution of costs over the entire field makes possible long-range stable industrial development. Forest industries in the past have been very largely single product industries. They have, in general, mined the forest with little regard for the future except in those old and stable countries where long experience has taught the necessity for good integration of forest use and growth. It is clear that the raw material offers broad opportunity for diversification and that permanence is best ensured by this means.

It is perhaps a truism to state that general human welfare, high levels of health and happiness, are correlated closely with economic prosperity and political stability. The latter two factors are generally inseparable. Fundamentally, the factor with which industrialization on a wood base has most to do is economic prosperity, which must be defined as a full satisfaction of human physical needs at the first level, and satisfaction of human "wants" at an increasingly higher level. There is no foreseeable limit to the height of the latter; it can only be limited by the amount of goods *in toto* capable of being produced by the application of human intelligence to the materials and sources of energy available to man.

The concept of an expanding economy involves both a broadening and deepening of production of goods; broadening the availability to include all peoples; and deepening the degree to which materials and energy are converted to human use. Wood is a raw material well nigh universal in its distribution, and, where not abundant, it can be grown in abundance on lands not fitted for other uses. It can become in truth the universal raw material upon which to base a major part of international activities that look toward not only the alleviation of the poverty that lies at the root of the world's ills, but the raising of the general level of availability of goods.

Urgent Problems for FAO

FAO would appear to offer an excellent medium for accomplishing certain necessary tasks preliminary to the wide industrial development based on wood that is contemplated. Undoubtedly, most such development must take place by the enlistment of private capital, which must be encouraged by accurate engineering and economic data as well as demonstration of the possibility of adequate markets. The importance of the material involved renders it international in character.

A central organization designed to collect, correlate, and review data on technical and industrial developments is of first importance. Research in forest products technology has been under way in many countries for many years, but dissemination of the information obtained has been left too much to chance, too much to scientific publications. The objective is the application of newly won scientific knowledge to actual industrial operation. Publication of scientific data is insufficient; it must be applied in an industrial way.

This can be accomplished through two principal processes: 1) the systematic dissemination of the information collected and analytically reviewed; and 2) the arranging of pilot and demonstration plants according to the special needs and possibilities of nations, regions, or territories. It has been apparent that there is a long time lag between production of research results in forest products utilization and their translation into industry. The lag arises partly from the inertia of industry and private capital and partly from the fact that most research in forest products utilization has been executed by governments. There has been inadequate opportunity for the transferring of scientific knowledge thus obtained into actual operating industries with full protection of public interest and opportunity for private gain. FAO should be in an excellent situation to bridge this gap, to adduce all available information on the subject and put it to work in the major task of drawing goods from the world's renewable forest wealth.

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The Growth of the World's Forests

By THE STAFF OF THE DIVISION OF FORESTRY AND FOREST PRODUCTS

ALMOST every country in the world is seriously concerned about the insufficient production of wood and, particularly, of lumber. The shortage is one of the principal obstacles to reconstruction in countries devastated by war, and even in the United States it is hampering the progress of construction programs. In view of the seriousness of the present situation, one might wonder whether such a shortage is likely to continue and whether the potential production of the forests of the world is really insufficient to satisfy the needs of its peoples.

The following article undertakes to show that, contrary to the usual belief, it is possible to foresee a more satisfactory situation for future production of wood and lumber, even though we limit ourselves to forests which are now accessible. Current developments, including greater study of these forests, improvements in methods of silviculture, and better utilization of forest products are reassuring trends to support an optimistic outlook.

Statistics of the FAO Copenhagen Conference

The report submitted to the Annual Conference in 1946 at Copenhagen and entitled *Forestry and Forest Products—World Situation 1937-1946* presents in its early pages a table containing data of great interest, not only to the economist and the statistician, but also to the silviculturist.

The portion of this table of special significance in our present study is reproduced as Table 1.

In spite of the inaccuracies inevitable in world-wide statistics of this sort, Table 1 shows that the average quantity of wood obtained annually by man from the total forest area at his disposal is about 0.4 m^3 per hectare. If we omit Europe, where annual yield reaches 2.3 m^3 per hectare, the average for the remainder of the world drops to 0.34 m^3 and in no region except Europe does it exceed 0.6 m^3. These figures are extremely low, even allowing for the fact that forest areas which are now inaccessible are included in the calculations. Nevertheless, we find that, in almost every country, competent forest authorities are constantly deploring the ill effects of the current exploitation of forests.

Fig. 1. Hill forest in India of Silver fir, Abies pindrow *Spach.*

Production per Hectare

In order to investigate the cause of this low production rate, it is worthwhile to examine the average rates at which the principal forest-producing countries of the world estimate the annual growth of their forests. Table 2 is based on information appearing in the appendix of the report cited above.

We have eliminated from Table 2 all countries for which statistics are lacking, and also all countries whose forests are chiefly of the equatorial or tropical type. Too little is known about tropical forests to permit the formulation of a sound opinion as to their ac-

Table 1.—Distribution of Forests, 1937

	Europe other than U.S.S.R.	U.S.S.R.	Middle East and N. Africa	North America	Central and South America	Africa other than North Africa	Southern and Eastern Asia	Pacific Area	World Total
Population in 1939 (millions)	392	178	98	143	130	115	1,099	11	2,166
Forest Area (million hectares)	132	960	41	635	815	512	500	54	3,650
Forest Area per caput (hectares)	0.3	5.4	0.4	4.4	6.3	4.4	0.4	4.9	1.7
Annual Cut									
Total (million m^3)	308	262	5	392	178	65	300	10	1,500
per hectare (m^3)	2.3	0.3	0.1	0.6	0.2	0.1	0.6	0.2	0.4
per caput (m^3)	0.8	1.5	0.05	2.7	1.4	0.4	0.3	0.9	0.7

TABLE 2.—FOREST AREAS, GROWTH, AND CUT

Country	Forest Area	Growth		Growth per hectare		Volume of Annual Cut
		Total	Net	Total	Net	
	million hectares	*million m³*		*m³*		*million m³*
British Isles	1.3	1.5	1.3	1.15	1.00	1.5
France	10.5	26.8	26.8	2.55	2.55	20.2
Belgium and Luxembourg	0.6	2.0	1.8	3.33	3.00	1.8
Netherlands	0.2	0.6	0.6	3.00	3.00	0.6
Denmark	0.4	2.4	2.4	6.00	6.00	2.1
Germany	12.6	41.7	41.7	3.31	3.31	56.0
Switzerland	0.9	3.1	3.1	3.44	3.44	3.2
Hungary	1.2	3.0	3.0	2.50	2.50	3.1
Spain	4.9	4.0	4.0	0.82	0.82	4.0
Italy	5.8	12.5	12.0	2.16	2.07	12.0
Greece	2.4	4.2	4.2	1.75	1.75	4.6
Norway	7.7	11.7	10.6	1.52	1.32	11.7
Sweden	23.1	47.6	42.0	2.06	1.82	45.0
Finland	38.3	45.7	39.7	1.19	1.04	47.6
Poland	8.5	18.0	16.4	2.12	1.93	17.7
Czechoslovakia	4.6	13.4	12.9	2.91	2.80	12.9
Austria	3.2	9.2	9.2	2.87	2.87	10.5
Portugal	2.3	9.0	9.0	3.91	3.91	9.0
Yugoslavia	8.1	16.0	16.0	1.98	1.98	22.6
Bulgaria	2.6	3.0	3.0	1.15	1.15	3.0
Rumania	6.5	25.0	18.0	3.85	2.77	18.6
Canada	334.5	154.0	80.0	0.46	0.24	67.0
Newfoundland	11.6	12.5	4.0	1.08	0.34	2.4
United States	255.2	319.8	248.3	1.25	0.97	322.0
Alaska	40.5	14.0	0.2	0.35	0.00	0.4
China	66.0	200.0	20.0	3.03	0.304	15.5
Japan	25.9	90.0	90.0	3.47	3.47	75.0
U. S. S. R.	960.0	630.0	262.0	0.66	0.27	262.0
New Zealand	5.3	3.1	2.3	0.58	0.43	2.3

tual rate of growth. Table 2 also covers most of the countries producing softwoods, and it is apparent that the major difficulties confronting the lumber trade throughout the world are caused by current shortages of softwoods. The most salient feature of the figures available for growth per hectare, both net or gross, is their diversity. Estimates of average gross increment vary from 0.35 m^3 for the forests of Alaska to 6 m^3 for those of Denmark.

It is evident that these disparities are caused in part by differences in natural conditions and in part by considerations of a statistical character. Figures stated in the "total" and "net" growth columns are based, in the case of some countries, on relatively precise knowledge. In regard to other countries, there have been various interpretations of the true state of affairs on the part of statisticians concerned.

FAO deems it to be one of its essential tasks to investigate this matter more thoroughly and to request each country to furnish detailed information as to its methods of computation. This task, however, will be long and difficult.

It is now proposed to investigate the different factors which have caused the diversity among the figures reported and, after analyzing these factors, to determine in what way the estimates could be adjusted to make them represent the real state of affairs; also, to determine in what way and under what conditions actual growth could be increased through improvements in silviculture.

Thus, our study will deal with two problems which at first sight, seem widely different. On the one hand, we will attempt to show how statistical information may be improved in order that the true situation in all countries may be set forth on a comparable basis. On the other hand, the question of statistics being disposed of, we will inquire whether it would be possible, through the application of appropriate silvicultural methods, to provide in the future an actual increase in the world's forest growth.

In the course of the present study, we recognize that these two problems are, in fact, closely linked. This is true because any improvement from a statistical point of view can be achieved only through a more thorough study of forests. But completion of our study is merely the first essential step toward the rational treatment of the forest and the adoption of silvicultural methods able to improve rates of growth. This article undertakes to show that progress toward solutions of both problems lies in the adoption of correct forest management—the word "management" being used here in its widest sense.

ACCURATE CALCULATION OF WOOD PRODUCTION

To begin with, it appears certain that most of the available figures on gross increment per hectare, that is to say, on total wood production, are nothing more than approximate estimates and are not based on complete measurements.

It is noteworthy, however, that the countries showing the highest figures are precisely those in which carefully controlled silvicultural methods have already been established for a long time; Denmark, 6 m^3; Japan, 3.7 m^3; Switzerland, 3.44 m^3; and Portugal, 3.91 m^3.

Actually, there is but one positive way of ascertaining the true production of wood in a forest and that is the method of repeated surveys or inventories at regular intervals. Actual production is then determined either by comparing volumes at the beginning and end of each period (making due allowance for trees cut down during the period) or by numerous increment borings.

It is true that a 100 percent inventory of large forests, such as is or should be commonly practiced in western Europe, is impracticable in the vast forest expanses of North America, or at best can be considered only as an ideal which might be reached in the remote future.

Sampling methods, based on the measurement of strips or plots, have been widely developed in North America during the last 30 years. These methods have been improved to a point where the composition of a forest by diameter classes can be determined as accurately as may be desired. The best results are obtained when sampling methods on the ground are used in conjunction with modern air photography. With these inventories as a starting point, actual production is usually determined by numerous increment borings, or by repeated re-measurement of selected sample plots at regular intervals.

It will easily be realized that the accuracy obtained from these methods depends primarily on the intensity of sampling and on the suitable location of the samples measured; hence, accuracy depends on the amount of existing knowledge as to the nature of the forests.

The more detailed the study of forests, the more accurate will be the estimate of their rate of growth; and it is interesting to note that, as survey methods have developed and been perfected, increasingly higher estimates of growth in the forests of the United States have been obtained. In 1931 the area of commercial forests was estimated by the United States Forest Service at 461.7 million acres (187 million hectares) and the standing timber at 519,000 million cubic feet (13,700 million m^3)—1,000 cubic feet per acre (70 m^3 per ha.)—while their annual growth was estimated at 8.900 million cubic feet (252 million m^3)—19 cubic feet per acre (1.37 m^3 per ha.). The annual rate of increase was, therefore, 1.83 percent. In 1945, on an area of 439 million acres (184 million ha.), the standing timber was estimated at 469,500 million cubic feet (13,000 million m^3)—1,044 cubic feet per acre (73 m^3 per ha.)—and annual growth was estimated at 13,300 million cubic feet (378 million m^3)—29 cubic feet per acre (2.05 m^3 per ha.)—giving a rate of increase of 2.8 percent.

A survey of the forest area and an inventory of the volume of standing timber should normally constitute the first step in the management of a forest. A complete survey and inventory, however, are not always made, and a great many forests are managed entirely on an area control basis and without any records of changes in volume from time to time. Except in the case of even-aged forests in which one compartment is clear-felled each year—and such cases are rare—the actual growth is unknown. As a matter of fact, serious mistakes have occurred through the rigid application of systems of management based solely on area control. This is most likely the reason why France, where there are a great many privately owned and unmanaged forests, shows a comparatively low estimate for average annual growth per hectare.

The facts we have just noted are particularly encouraging since we are justified in believing that the more we know about the forests and the more intensively they are managed, the higher will the estimates of their actual growth become. There is no doubt that forestry experts tend to underestimate annual growth, and for this they can hardly be blamed by anyone who realizes the danger of excessive felling which overevaluation would entail. We are certain, however, that, even in the case of countries already showing substantial figures for total growth per hectare, still larger estimates may be expected to arise from a more careful study of the forests.

Fig. 2. Tree sampling in the United States.

Total Forest Area and Unproductive Forests

In Table 2 the estimated figures for total growth were divided by the total areas of the forests in order to determine average growth per hectare. It is known, however, that the total forest area reported, representing 27.6 percent of the land area of the world, includes areas that are forests in name only. For example, some areas in the dry southern regions and on mountain slopes in Europe and America bear only scrubby trees which cannot even be used for fuel because of their remoteness from inhabited centers. Others, in the northern regions, bear only deformed and extremely small trees whose development is limited by the shortness of the growing season. These areas are very extensive and their production of wood, while not absolutely nonexistent, is very low. Because the wood they do produce has little or no value, they will always remain useless to man as a source of forest products. Even if they should become accessible in the future, through development of transportation systems, their net growth is negligible and will probably remain so.

The inclusion in the total forest area of such tree-covered lands as are described in the preceding paragraph, is obviously the main reason why production per hectare in many countries, and particularly in the northern countries, appears so low. This is certainly true in the cases of Russia, Canada, Newfoundland, and Alaska.

Real difficulties are entailed by the inclusion of

these nonproductive forests in calculations of growth per hectare, because the low figures derived are apt to make forestry experts unduly cautious with regard to the real growth of productive forests.

It would be preferable to place these areas in the category to which they really belong, that is, unproductive lands. In a sense, their broad classification would be the same as that of the polar regions or of high mountain tops. The only difference is that some of the nonproductive forests might eventually be transformed to a productive condition. This, however, would be a slow process and would probably be impossible in the case of large areas.

At any rate, a more accurate determination of the area of these unproductive forest lands will permit a more precise determination of the average rate of growth of productive forests. The new averages would be higher than the figures we now possess, even though more accurate measurement will not, in itself, increase growth rates. What is needed is simply more reconnaissance work in those countries where it is not yet complete, as well as improved statistical evaluations on which FAO is already working.

Total and Net Growth in Inaccessible Forests

In densely populated countries where forests are intensively managed and in which available means of transportation give easy access for the removal of timber by tractors, cable systems, etc., all the wood which falls in the forest, whether it is felled or falls as a result of wind, insects, fire, disease, or old age, is ordinarily considered as part of the production of a forest and is used in some manner by man. The only limiting condition is that the market value or utility of the wood, when transported to the place where it is to be used, must be sufficiently high to cover the costs of stumpage, felling, and transportation. In countries such as are described above, this condition is usually fulfilled, although exceptions occur when the fallen trees are rendered worthless by rot or by fire, or when they happen to lie in places from which removal is too costly. Under normal conditions the total wood production in the forest can be acquired by man. It may happen that for various reasons a volume either greater or smaller than the actual growth is felled but, in any case, the whole of the

Fig. 3. Virgin stand of Douglas fir, Pseudolsuga taxifolia *Britt., in the United States*

volume harvested becomes available for man's use.

Under the conditions outlined in the previous paragraph we consider that net growth is equal to total growth, which is the reason why, for most of the countries of western Europe, the tabulated figures for both types of growth are identical. It is somewhat surprising to find that in the case of certain countries such as the United Kingdom, Belgium, and Poland, there are considerable differences between these figures, while there is absolute agreement for other countries. It is evident that here we have certain anomalies in

constant, except for minor variations.

Actual growth is offset by an equal volume of trees which die or fall in the forests and which, although they may be fit for man's use at the time of their fall, will in fact remain untouched because that forest is inaccessible and their removal is economically impracticable. Such a forest, therefore, has a gross increment but its net increment is nil.

Virgin forests extend over considerable areas in North America, Russia, and in the Scandinavian countries. Tropical countries, of course, have vast expanses

Fig. 4. Virgin forest of redwoods, Sequoia sempervirens *Endl., in the United States*

estimating net growth which are of a purely statistical nature and which can readily be rectified. The necessary corrections would in no way affect the figures for total production per hectare.

If, on the other hand, we consider virgin forests, we may find that they too show an actual growth of wood. Such net growth does not accumulate indefinitely. This is proved by referring to certain inventories carried out in virgin forests, particularly in virgin forests of fir in the Balkans; moreover, common sense shows that the composition and the volume of a virgin forest must necessarily remain relatively

of such forests.

In our present figures on growth, two different methods of computation are found to be in use. In the first instance, the countries concerned may not have included growth in virgin forests in their estimates of total increment. As in the case of the unproductive forests previously considered, total growth per hectare, as well as net growth, obviously stands at very low figures; but the situation is different here because these inaccessible forests form a potentially productive reserve. When compelled by necessity or when the means at his disposal have become adequate, man will

be able to extract from these forests a volume of timber equal to their potential net growth. For a while he may be able to cut even more than the net annual growth because of accumulated reserves of large timber. Total growth for the country will thus show an increase and so will net growth and, of course, the estimated average growth per unit of area for the country as a whole will be increased.

In the second instance, the countries concerned, while including gross increment of virgin forests in their figures for total growth, naturally do not incorporate it in their net growth. This would explain the wide disparity noted between total and net growth for certain countries such as the U. S. S. R. But, even in this case, the method by which these virgin forests were evaluated is not quite clear. In the case of such forests, sample plots are of very little help, since the comparative stability of the stand, to which we have previously referred, may be observed only over wide areas exceeding at least 100 hectares. In any case, if only as a measure of caution, their growth was probably estimated most conservatively. Even if the figure arrived at should be accurate, this evaluation would, no doubt, increase soon after the forest was put under systematic management. Well-managed cuts, while singling out choice specimens and promoting regeneration, would, at the same time, bring about a higher rate of growth even though the growing stock was reduced.

Consequently, we believe that in all cases the opening up of virgin forests will, if ruthless and excessive fellings are avoided, lead to an increase in estimates of average growth per hectare.

It is true that changing conditions which lead man to investigate the opening up of new forests do not all operate in one direction and that, given certain economic conditions, it may become necessary to withdraw from other forests. This happened before the Second World War in western European countries which had large coppice forests whose products no longer had a market because of the competition of coal. These forests were undoubtedly in danger of reverting to a "virgin" state. In any case, we are dealing here with a temporary phenomenon of relatively small importance which could, even though repeated, have no more than a slight influence on wood statistics.

The Wastage of Wood

Between the systematically managed forest and the virgin forest, all intermediate stages are possible. In one region, with sparse population, one may find a forest in which normal fellings are regularly carried out but where the incidental products, distributed for the most part over wide areas, are not extracted or are only partially extracted from the forests.

In other regions, the remoteness of the forest and the necessity for providing expensive means of extraction for each partial cutting make it necessary to concentrate the fellings within small areas and, consequently, to work on a program of long felling cycles with the removal of large volumes at each felling. Between fellings the incidental products are not extracted; and, even when the fellings are made, inferior specimens, the market value of which would be less than the cost of removal and transportation, are left behind. In certain forests of the Karst, for instance, although systematic management is in force, economic necessity compels the adoption of felling cycles of some 22 to 25 years in the better forests where the rate of increase may be about 2 percent, so that 40 to 50 percent of the growing stock may be felled in one operation. In other cases, economic pressure may compel almost wholesale clear-felling. In such cases, there is likely to be a loss of productive capacity of the soil because regeneration may take a long time.

From a statistical point of view, the wastage of wood tends to increase the difference between estimated total growth and net growth. It is obviously for this reason that the difference is most marked in the countries which are still rich in virgin forests: Canada, the U.S.S.R., and the United States. But the phenomena under discussion undoubtedly influence both total production and growth per hectare. In most, if not all, cases the greatest yield is obtainable from a forest through light fellings repeated at short intervals, although the regeneration of some species may require small clear-fellings at the end of a rotation. The silviculturist is thus given the opportunity to act at the right time to ensure the extraction of the best trees and to hasten regeneration; furthermore, if he is adequately equipped to estimate growth accurately, he may concentrate the greater part of his operations in the way best suited to further the interest of the stand.

It is a foregone conclusion that as the conditions of accessibility of a forest improve — particularly when its products become increasingly easy to reach — it will become possible to apply silvicultural methods which will increase growth per hectare and, at the same time, the difference between total and net growth will decrease to a point where it will eventually disappear.

Natural Factors and Silvicultural Methods

As a rule, in moving from south to north within the North Temperate Zone, the average annual growth per hectare decreases. There are, however, notable exceptions, such as Denmark, in which a very high average growth per hectare is obtained partly, perhaps, because the forests are growing on rich agricultural soils.

This tendency toward lower production in the higher latitudes results from an increasing severity of the climate, and it is evidently useless to hope that the production per hectare of the Scandinavian forests will ever reach the figure attained, for example, in Switzerland.

The Swiss Alps and the French Alps, however, contain many forests situated at high altitudes where climatic conditions are comparable to those of the northern countries. A great many identical species are to be found in the forests of both Switzerland and Scandinavia, although there may be differences in strains. On the other hand, the appearance and the production of these forests differ so widely that one might inquire, at a time when the most intensive cultivation of presently accessible forest lands is imperatively needed, whether the degree of perfection of silvicultural methods in use is not in itself a most important factor in accounting for the variations noted in production per hectare between different parts of the world.

In comparing the northern forests—and, for that

matter, the forests of many other countries enjoying more favorable climatic conditions — with those of Switzerland, we find that the former have only fair to low stands per hectare (at times less than 60 m^3) and trees of very small average diameter.

The smallness of the stands of timber per hectare in the north is due chiefly to the small diameters of the trees which the sites, conditioned by soil and climate, are capable of producing. It hardly seems possible to modify to any considerable extent the limits imposed by nature on the productive capacity of the soil. Recent studies, however, on selection and hybridization now in progress in the United States, the Scandinavian countries, and Portugal give rise to many hopes. Although at the outset certain silviculturists feared that the quantity of timber could be increased only at the expense of quality, these apprehensions are today proving unjustified, especially because wood utilization techniques are undergoing great alterations and may, in the future, require precisely the qualities that accompany rapid growth. But, leaving aside the possibilities of applying the findings of this new research work, the question may still be put as to whether the small number of trees per hectare found in some of these stands is not due to deficiencies of natural regeneration. In considering this aspect of the question, we can exclude the most northerly forests which form a necessary transition between the true productive forests and the unproductive lands, wrongly called forests, to which we have referred above.

Where natural regeneration is insufficient, conditions could be improved either through a better adaptation of silvicultural methods to local conditions or by having recourse to planting. It must be remembered, however, that application of either of these remedies requires that the forests concerned should be at least reasonably accessible. Extreme remoteness of forests and difficult conditions of transportation inevitably give rise to wholesale felling, which makes regeneration difficult if the species in question does not naturally happen to react favorably. Furthermore, the establishment of new plantings, which require much manpower not only for the planting operation, but also for the upkeep of nurseries in the vicinity, is difficult, if not impossible, in very remote areas.

In any case, failure to obtain adequate forest regeneration cannot be charged merely to certain particular countries. Even in the most carefully developed forests, there are lands exposed by openings, caused by windfall or by badly planned fellings, where natural regeneration was too heavily depended upon for rehabilitation. The nature of the various species suitable for use in reforestation is now sufficiently well known, and the choice of varieties is usually large enough to prevent hesitation as to the advisability of having recourse to artificial regeneration because of fear of failure. The above should not be construed to mean that artificial regeneration should always be the rule, because, apart from difficulties of cultivation, it might impose upon the forest an expenditure which it would not always be in a position to bear. But, in principle, it should be considered abnormal for recently logged forest land to remain unproductive for several years, and, when this occurs, artificial regeneration should be undertaken.

There is also the question as to the ideal average diameter of the trees composing a forest. There has been much discussion of this question, but not enough practical and accurate research upon it. At least, research has too often been directed toward the study of regular stands; while the possibilities of the even-aged forest, which, through an intelligently planned arrangement, allows the maximum possible production to be extracted from each tree, have too often been neglected.

Insofar as softwoods are concerned, there is at present a tendency toward the harvesting of trees of small diameter due to the development of a market for this class of material. Forests which are managed entirely for the production of small diameter material and therefore on a short rotation, are attractive to forest owners because they yield a comparatively high rate of interest on the investment, a fact which will facilitate reforestation.

Japan is probably the country where one finds the most typical case of limitation of exploitable diameter. In managed forests the average tree does not exceed 30 to 35 cm. and the rotation is 80 years at the most and more generally, 50 to 60 years. On the other hand, the average volume per hectare is usually much lower than 200 m^3. This limitation is possibly due in part to the fact that logging operations are mostly conducted by hand; it is, however, also based on yield tables which at first sight appear conclusive and tend to show that, at the above ages, a noticeable reduction in the annual growth per hectare actually takes place.

Nevertheless, such yield tables, drawn up under very special conditions, seem to call for some reservation, and in the forests of western Europe it seems that the forests which are the richest in material and particularly in large timber provide the largest growth per hectare, attaining or exceeding 10 m^3 annually. Of course, the volume of such stands increases at a relatively low rate and the method involves the immobilization of a considerable capital, but the soil produces at its maximum capacity.

We have to choose between two different policies, but in the present period of shortage it would seem desirable to extract from every hectare of forest land the highest rate of growth attainable; always providing, of course, that this is compatible with economic conditions, good quality of the products, and the proper maintenance of the forests.

In our estimation silvicultural research has not been pursued far enough in the different countries to determine finally the best forest policy for each one. On the other hand, current research on selection of species, hybridization, reproduction by sprouts, the action of mycorrhiza, etc., may well alter conclusions which have already been reached.

Whatever the findings of research may be, they are likely to show the necessity for major reforms. For example, it may be demonstrated that the timber or pulp industries should direct their attention to the utilization of wood of a smaller or a larger average diameter, with corresponding changes in present manufacturing methods. It may be shown that nations should take all possible measures to improve their silviculture and to extend the benefits of new methods to privately owned forests. It is also likely that inquiry will show the advisability of adopting different policies to suit different countries, according to their relative degrees of forest wealth.

In any case, the question is of the utmost importance and there is no doubt that, whatever the reaction

to it in various countries, increased growth per hectare is bound to result from an improvement in silvicultural methods.

Outlook and Remedies

In general, it has been shown that higher figures for average yield per hectare should result from increased knowledge of the existing forests, the adoption of more intensive silvicultural methods, and the more skillful use of forest products.

Even today, true yields per hectare are probably higher than is generally indicated by statistics which are often based on mere estimates or on methods of computation which are themselves in the course of development.

Finally, increased net yield depends to a large extent on man, who has it in his power to increase the forest output sufficiently to meet all his needs and at the same time to maintain the forests in good condition. The unique feature of forest management is the fact that the obtaining of a harvest implies the removal of a part of the growing stock. The task of the silviculturist, therefore, consists in seeing to it that the extracted material is duly replaced, that annual growth occurs in the required quantity on a reduced number of stems, and lastly, that both these objectives are attained at the same time.

All the measures which have been suggested in the preceding paragraph for improving existing figures of production per hectare, either statistically or in fact, may be summed up in a single requirement, namely, improved management of the forest. The word "management," however, should be used in its broad sense and not restricted to mean merely that the rate of fellings and their distribution by areas should be subjected to regulation. Regulation of fellings is indeed necessary, but there are many other factors which must be taken into consideration if any plan of regulation is to be made practicable.

Since the term "forest management" appears to be used in different senses in different parts of the world, it appears worthwhile to discuss briefly its broader and narrower meanings, and the way in which they ought to be combined if we are to reach the objective of increased total and net yields per hectare.

Management in Its Wider Sense

It is the object of forest management to give to man full possession and control of the forest. Its first stage is logically the full and careful study of all such forests as are likely to produce wood and the precise limitation of their boundaries. In many countries of the world, this stage is very far from being attained.

The second stage is the protection of the forest against its enemies. This means chiefly protection against fire, since protection against injurious outbreaks of forest insects and tree diseases must depend chiefly on silvicultural measures.

It is true that adequate control of fire requires a network of roads, giving ready access to the forest area, but developments in recent years have shown that, even in the case of so-called inaccessible forests, man now has at his disposal means which enable him to organize some degree of fire control. In this stage of forest management, the United States has reached a position of leadership. Through the adoption of modern methods, including aircraft, radio, and automotive equipment for the prevention and suppression of fires, and through painstaking attention to the small details of organization and equipment, American forestry experts have made remarkable progress in the control of forest fires. In certain parts of the United States, fire has even been used as a positive element in applied silviculture, and may yet prove to be more important in this respect than has previously been recognized.

The third stage of management, which has not yet been fully attained even in some of those countries where intensive silviculture has been practiced for a long time, aims to put the products of the forest within economic reach of the user. This stage consists in the provision of means of communication and transportation required for the economic development of the whole forest area.

The fourth and last stage consists in finding adequate markets for the products of the forest and, so far as possible, for *all* of the products. This stage is, of course, closely related to the third, because the building of transportation systems, involving large capital expenditures, cannot be undertaken unless it can be shown that the value of the products to be obtained will justify the investment. In many cases, a forest cannot be rationally developed unless man creates new industries—sawmills, pulp mills, etc.—for the conversion of its products. In general, it is desirable to have converting industries near the forest, because raw wood is heavy, bulky, and of relatively low value so that it cannot bear very high transportation costs. Once the timber is converted to lighter and more valuable products, transportation costs can more easily be supported. Although, in general, it seems desirable to have conversion plants near the forest, an exception exists where logs can easily be floated down rivers for long distances at very low cost. This fourth stage of management may even include efforts to organize new local or world-wide markets which will be able to absorb all or part of the products of the newly developed forest. Therefore it calls for a wide knowledge of trade requirements for forest products, and from this point of view it may be expected that an international organization such as FAO will in the future be called upon to play a leading role.

Forest management, in its broad sense, is thus a long and exacting process which as a rule involves the investment of considerable amounts of capital. Very often, it implies national or even international action, either direct or indirect. Direct action may consist of organization of surveying expeditions into unexplored forests; of construction of communication and transportation systems, and the establishment of industries or the provision of financial assistance for them; of supplying adequate technical personnel capable of planning and carrying out the necessary operations; and of analyzing and securing the markets necessary to the disposal of products. Nations may act indirectly by drawing up forestry laws, which should be as inclusive as possible and properly adapted to actual conditions existing in each country. Those nations whose forests boast the highest yields per hectare are also those whose forest legislation is the oldest and the most comprehensive.

Forest Management in the Limited Sense

The more limited aspect of forest management applies to the individual forest owner rather than to the nations themselves. It should be noted, however, that in most countries the government is a major forest owner and that it can and must play an extremely important part even in private forestry by means of demonstration, public education, and perhaps control.

The principles upon which proper management should be based are not always, nor everywhere, definitely laid down. Silvicultural research takes time and patience. It also implies government participation and even co-operation between governments. An example furnished in this article was the possible choice between the policies of producing small timber on short rotations or large timber on long rotations.

In any case, management in the restricted sense consists of determining the permissible annual yield of the forest and in calculating the proper intensity and distribution of the fellings required to produce that yield, including necessary operations for forest improvement. It consists also in regulation of the timing of these fellings in such a way as to safeguard the best interests both of the forest and its owner. It implies the carrying out, at regular intervals, of accurate inventories of the forest in order to detect fluctuations of growth and to note progress or regression of the growing stock. Periodic expenditures for inventories should normally be regarded as an ordinary part of forest management expenditures because this measure, which every forest owner should look upon as an obligation, is essential to the proper maintenance of the forest.

We have already shown that management in the narrow sense is possible only when the requisite conditions have been established through application of the principles implied by management in its broader sense. It would be purely an academic exercise to attempt to regulate fellings in a forest where the boundaries were not determined, in one whose very existence was constantly threatened by fire, in a forest where no fellings were possible because there would be no means for removing the products, or in one for whose products no market exists.

Fig. 5. Effects of erosion

There are, no doubt, forests that are being managed in spite of the fact that some of the above conditions exist. Management under such conditions, however, must depart more or less from the principles of silviculture upon which it should be based. This is inevitable because of economic difficulties. Thus, the management of a forest lacking permanent transportation systems must necessarily be based on such long cutting cycles that silvicultural operations cannot be undertaken with any hope of success. We may say that management under these circumstances means a compromise between cultural and economic necessities

and, unfortunately, too many operations, even in the more advanced countries, must be placed in this class.

Fig. 6. Plantation of teak, Tectona grandis *L. f.*

However, the gap between economic and cultural necessities tends to become smaller. Progress will, no doubt, be slow in countries where vast forest areas are still out of man's reach, and where management in the broad sense is just commencing. But, under the pressure of ever increasing requirements for wood implicit in the progress of civilization, man will be forced to have recourse to those resources which are as yet undeveloped. Furthermore, under the same pressure, and particularly if the initiative is taken by governments, he will strive everywhere to derive the maximum possible production from the forest lands already at his disposal. The improvement of silvicultural methods will be of tremendous help. In the field of forestry, progress is on the march, and it is up to the forestry experts of all nations to contribute their knowledge and enthusiasm. Their reward will come when world statistics show increases in the low figures for average yields per hectare which today are characteristic of the great majority of the world's forests.

The cause at stake is well worth whatever efforts are needed. Forest lands are not, in fact, merely poor relatives of agricultural lands, as is so often believed. The usefulness of their products cannot, of course, be compared direcly with that of food, but, in a different sense, this usefulness is as great as that of agricultural lands whose value and ability to produce often depend, to a large extent, on the protection the forest affords them.

Insofar as production is concerned, the output of forest lands, though it requires far less effort and expenditure, yet compares favorably with that of agricultural lands. One hectare of forest land in good condition can produce annually 10 m^3 of timber, or, in terms of seasoned wood, 5,000 kg. of material suitable for man's use. On the other hand, one hectare of corn produces a yearly crop of about 1,800 kg. of food products, and a hectare of cotton may produce only 300 kg. The forest then, while assuring the protection essential to agricultural land, is itself a source of such wealth that no effort should be spared to increase its productive power.

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Timber Shortage or Timber Abundance in the U.S.A.

By LYLE F. WATTS
Chief of the United States Forest Service

This article is part of the official report submitted in 1946 by Mr. Watts, Chief of the United States Forest Service, to the Secretary of Agriculture. It was thought that this report was of such outstanding interest that even though it had already been published, it should be made available to the readers of UNASYLVA. Especially to readers outside the United States of America, it will present an authoritative and engrossing picture of forestry conditions in that country and of the efforts being made to bring full-scale systematic forest management to a nation that has realized that even its own "unlimited resources" need care and husbandry. There can be no doubt that what Mr. Watts has to say cannot be repeated often enough.

The Division of Forestry and Forest Products of FAO wishes to acknowledge its indebtedness to the United States Department of Agriculture for permission to publish this text.

OUR forests today are not supplying enough timber products. While thousands search desperately for places to live, construction of urgently needed dwellings is hampered by lack of building materials. Lumber is perhaps the number one bottleneck. Plywood also is seriously short. Our special efforts to meet housing needs have caused restrictions on other essential uses of lumber—for business and industrial construction and repair, for farm buildings, for manufacturing numerous products, for boxes and crates to move commodities to consumers. We are now unable to meet world-wide needs for lumber exports. Pulp and paper are short, with demands mounting. Newsprint supplies are still restricted.

Manpower shortages and the shortage of operating equipment, supplies, and repair parts were major factors affecting lumber production during the war years. Some of these difficulties, together with labor unrest, continued to retard production in 1946.

These are temporary difficulties. It has become increasingly evident, however, that shortage of standing timber in many localities is a major deterrent to increased lumber production. And this is not a matter that can quickly be remedied. Long before the war, timber shortage had curtailed output in the older timber-producing regions—New England, Pennsylvania, and the Lake States. During 1946, shortages of pine timber big enough to make good lumber were pronounced in various parts of the South. Even in the West some localities are feeling the pinch; industry is reaching toward the more remote stands of timber, searching for new "logging chances."

A rapidly growing pulp and paper industry is competing with lumber producers for available timber. Heavy demand for poles and piling likewise means competition for available timber, especially in the South.

The plain fact is that our supply of readily accessible, merchantable standing timber is running low. Sufficient manpower, equipment, and sawmill capacity no doubt will be available in the next few years for a much larger output of lumber, but the increasing scarcity of good timber will continue to limit the level of production.

The present shortage of timber products, therefore, will not be of short duration. It will last until we grow a great deal more saw timber, and you can't grow trees of saw-timber size overnight. We are becoming more and more dependent on the size of our annual timber crop. And our annual timber crop is not big enough to supply the nation's present appetite for timber products. It it far short of what we are likely to need for a strong, expanding economy in the future.

For years, every annual report of the Forest Service has warned that we cannot continue to eat into our forest capital without serious consequences. The Forest Service does not wish, however, merely to say "I told you so." Rather, it would emphasize, with all the strength it can command, that we *can* grow the timber we need, and that it is high time we increased our efforts to do so.

The World Forest Situation

Timber shortage is general throughout most of the civilized world. The Technical Committee on Forestry and Primary Forest Products of the United Nations Interim Commission on Food and Agriculture reported in 1944 that—

"In the face of . . . . rapidly multiplying uses for wood which create ever-mounting wood needs, the world is confronted by the inescapable fact that the forests—sole source of wood—are steadily diminishing."

Fig. 1. State-owned virgin mixed hardwood timber in Wisconsin

Over 60 percent of the softwood timber upon which the world depends for construction material is in North America and Europe. Of the once heavily forested continent of Europe, the report says, only three countries now have appreciable quantities of timber beyond their national needs. Life among the crowded millions in China and India is forced to adjust itself to the privations imposed by chronic wood starvation.

Today less than 15 percent of the world's timberlands are being handled as a renewable, continuously productive resource, the committee states. About two-thirds of the world's forests receive neither care nor protection.

We cannot look to foreign sources, therefore, to supply any substantial part of our lumber needs. Europe and Asia cannot meet their own. The undeveloped forest resources of the tropics may supply greater quantities of cabinet woods and specialty items, but they cannot take the place of the coniferous forest of the Temperate Zone. During the war years, Canada supplied us with about a thousand million board feet (2.36 million m^3)[1] of lumber a year. We can expect little if any more in the postwar years. Canada, like the United States of America, faces a dwindling supply of accessible saw timber, and other nations besides us are clamoring for Canada's present exportable surplus.

[1]Converting factors for board feet differ according to whether reference is to sawn logs or round logs. 1,000 board feet of round logs = 4.53 m^3; 1,000 board feet of sawn timber (solid content) = 2.36 m^3.

Even now we are importing about a third of our pulp and paper, largely from Canada. We can look to some increase in the supply from our northern neighbor, but, by and large, any increase in our requirements for pulp and paper products will have to be met by our own production.

So, in large part, we shall have to grow our own. We would do well, moreover, to work for an annual timber crop large enough to provide liberally for domestic requirements, to increase the opportunity for healthy export trade, and to create reserves to draw on in time of need as a measure of national security.

In working for timber abundance, we shall at the same time be increasing the many other values and benefits that thriving, well cared for forests give. We shall be improving the protection of watersheds, safeguarding water supplies, reducing the menace of floods. We shall increase the opportunities for wholesome outdoor recreation; improve habitat for wildlife. We shall provide a better economic background for sound community development in forest regions. We shall restore scenic beauty to ugly areas of depletion, make our country a yet more pleasant one in which to live.

The United States Timber Supply

During 1945-46 the Forest Service made a reappraisal of the nation's forest resources in order to check up on current trends in the forest situation, evaluate progress, and provide an up-to-date factual basis for conservation objectives and policies. The results will be made available in detailed reports; only some of the high lights need be given here. They show plenty of cause for concern.

In 1909 the Bureau of Corporations estimated the total stand of saw timber in the United States of America at 2,826 thousand million board feet (12,800 million m^3). The reappraisal estimate, as of 1945, is 1,601 thousand million board feet (7,250 million m^3). This would indicate that in 36 years the nation's wood pile has been reduced by 44 percent.

There is every reason to believe that the drop in volume of standing timber since 1909 is much greater than indicated. Many kinds of trees which were then considered of no value are now being used and are included in the 1945 estimate. Also much smaller trees are classed as saw timber these days, especially in the eastern half of the country. (Saw timber in the reappraisal estimate means all trees big enough to saw into lumber, whether used for that purpose or not.)

The reappraisal estimate of the nation's saw-timber stand is 9 percent less than the estimate made by the Forest Service in 1938 for the Joint Congressional Committee on Forestry.

These over-all figures do not show the full picture as to character of timber, trends within states, or as to individual species of trees. More than half of the present total saw-timber stand is in what is left of our virgin forests; 96 percent of the virgin timber is in the Western States. But not all virgin timber is high-quality timber. Perhaps a third of it is of relatively low-value types, such as lodgepole pine, *Pinus contorta* Dougl.

The second-growth stands, upon which we are becoming more and more dependent, are not producing

Fig. 2. Trappers Lake in Colorado

the quality and kinds of timber needed for many uses.

In Mississippi the saw-timber volume of all species has declined 15 percent since the middle thirties. But there has been a 32-percent decline in the volume of pine—the state's most important timber species. In northeast Mississippi, pine volume dropped 64 percent.

In New England and the Middle Atlantic States, high-grade white pine, *Pinus strobus* L., is practically a thing of the past. In the Lake States there is in sight at the present rate of drain only a 6- to 8-year supply of yellow birch, *Betula lutea* Michx., suitable for the high-quality veneer so much in demand during the war. Indications are that there is not enough spruce in the Lake States to sustain the present demand for spruce pulpwood another 20 years. One Wisconsin pulp mill is bringing wood a thousand miles from the Rocky Mountains.

Hickory handle material is growing scarce in the Central States. Barrel makers are combing large areas for white oak, *Quercus alba* L., stave material. The supply of white oak that will meet the requirements for ship timbers is already virtually exhausted.

In the South, stands of softwood trees that would yield large, heavy structural timbers are getting scarce. Several hardwood sawmills have closed because of the scarcity of quality logs.

The quality situation is beginning to tighten up in the West also. The supply of Sitka spruce, *Picea sitchensis* Carr., suitable for aircraft use was inadequate to meet wartime needs. Competition is becoming more intense between plywood manufacturers and lumber mills for Douglas-fir, *Pseudotsuga taxifolia* Britt., logs of peeler grade.

Quality decline is noticeable not only in the growing scarcity of choice, sought-after trees, but in the general deterioration of many timber stands. Long years of "creaming" the forests for desirable timber has resulted in reduction in the percentage of valuable species, and a consequent increase in the proportion of low-value trees. Large areas in New England, for example, have been taken over by such inferior species as gray birch, *Betula populifolia* Ait., aspen, *Populus tremuloïdes*, and pin-cherry, *Prunus pennsylvanica* L., or highly defective trees of the better species. Clear-cutting the second-growth hardwood has resulted in stump-sprout stands of value only for fuel wood or other low-grade products.

Destructive logging and repeated burning since colonial times have reduced three-quarters of a million acres (300,000 hectares) of oak-pine land in New Jersey to a virtually nonproductive status. Similar conditions in eastern Pennsylvania have converted large areas to scrub oak. Millions of acres of former pine lands in the Lake States now bear scrubby stands of aspen and oak. A considerable acreage in the Ohio Valley States is restocking to low-value sassafras, *Sassafras variifolium* Ktze., and persimmon, *Diospyros virginiana* L.

In the South, longleaf pine, *Pinus palustris* Mill., has been succeeded by scrub oak on more than 2 million acres (800,000 hectares). Inferior growth of hackberry, *Celtis occidentalis* L., elm, *Ulmus*, spp., ash, *Fraxinus*, spp., has replaced valuable oaks and sweetgum, *Liquidambar styraciflua*, on 10 to 15 percent of the Mississippi Delta forest area. In the Piedmont of North Carolina, entire counties are now mostly covered with scrub hardwoods because the mills

have virtually exhausted the pine timber and better hardwoods.

In the eastern half of the United States, there is a general downward trend in tree sizes. You can find mills cutting ridiculously small logs for lack of reasonably large timber. A survey of 118 plants in the Northeast showed that the average log size for 69 of these mills was 10 inches (25 cm.) or less. A canvass of hardwood mills in the Mississippi Delta revealed that many plants are operating on logs one-half or one-third as large as formerly. With small trees it costs more to saw the same amount of lumber. And you get a poorer grade of material. You cannot get big, choice, wide boards from tiny trees.

Present Growth vs. Present Drain

In 1944 we took from our forests for lumber, fuel wood, pulpwood, and other products some 12,200 million cubic feet (345 million m^3) of wood. To this must be added some 1,500 million cubic feet (42.5 million m^3) lost as a result of fire, wind, and ice storms, and damage by insects and tree diseases. This makes a total annual drain of 13,700 million cubic feet (387.5 million m^3). Against this drain, the amount of wood added to our timber stand each year by growth is estimated at 13,400 million cubic feet (379.2 million m^3). In this near-balance, we must remember, however, that much of the drain is of high-quality material, while the growth is generally of poorer quality.

But in trees of saw-timber size—and the bulk of our forest industry depends on saw timber—drain is at the rate of 53,900 million board feet (244 million m^3), while annual growth is only 35,300 million board feet (160 million m^3). Saw-timber drain thus exceeds growth by more than 50 percent.

We are overdrawing our saw-timber bank account by about 18,600 million board feet (84 million m^3) a year.

We can reduce the drain from natural causes by tighter fire protection and by more intensive warfare against destructive insects and diseases. Common sense dictates that loss and waste from such causes be reduced to the minimum.

But about 90 percent of the total drain comes from cutting timber for use. And we are still not getting as much timber as we need. The answer obviously, for the long pull, is to grow more timber. Meanwhile, some drastic adjustments are inevitable.

If prevailing practices and present rate of cut region by region were to continue, we could look to a further reduction of some 27 percent in our timber resources in another 20 years. Moreover, intensified search for high-quality trees would lead to a significant reduction in average quality of the saw timber that remains.

In board-foot volume, the greatest reduction of saw-timber stand is taking place in the Pacific Northwest. A 40-percent decline in 20 years is in prospect here. This would mean a reduction in saw-timber stand from its present 630,000 million feet (2,850 million m^3) to 383,000 million (1,720 million m^3).

Western forest industries grew up and still operate, in the main, on virgin timber. As new opportunities for operation in virgin stands play out, the West Coast States will be unable to maintain the present level of production. The West must look to its second growth for the future. There is danger that some of the second-growth stands in private ownership may be improperly and prematurely cut. This is already happening. An increasing number of small mills are stripping off the second growth, consuming the industry's future timber stocks.

The South has been optimistic about its timber future. But for the South as a whole, 20 years more of the present cut under prevailing practices would mean a reduction of one-third in the volume of saw-timber growing stock. For the Southeastern States alone, with drain currently 3,500 million feet (16 million m^3) annually in excess of growth, growing stock is on a decline that will, if continued, reduce the saw-timber stand about 60 percent in the next 20 years. Since the South now accounts for about 45 percent of our total lumber production, timber depletion in this region materially affects the national production outlook.

Other eastern regions, producing about 10 percent of the nation's total lumber cut and 16 percent of the saw timber cut for all uses, have insufficient saw timber of suitable size and quality even to sustain present production levels much longer. Throughout these regions—New England, the Middle Atlantic, Central, and Lake States—the big problem is one of building up the forest capital, or growing stock. With 36 percent of the country's total commercial forest area, they are capable eventually of producing a much greater share of the nation's annual saw-timber supply.

Prevailing Cutting Practice

A field survey of prevailing methods of cutting was made for the first time as part of the reappraisal.

The analysis shows that a majority of large owners are doing a fair or better job. On nearly 30 percent of the operating forest land in industrial or other large private holdings cutting practice is good. But on the much larger area in small private holdings a high percentage of cutting practice is poor or destructive.

For all private forest land, cutting practice on 64 percent is classed as poor to destructive. Twenty-eight percent rates as fair; 7 percent as good. Only 1 percent is classed as of a high order.

Good cutting practice keeps the forest land continuously productive. It follows principles developed through years of research and experience in scientific forestry. It leaves the forest in condition to keep on yielding other and often better crops of timber.

Poor cutting practice strips the land of all present values without thought of the future. Or it mows down young stands prematurely, before they have reached the period of most productive growth. Or it high-grades the stand, taking out the best species and leaving a residue of poor, low-value trees. It is the type of cutting that has resulted in progressive deterioration of large areas of our forests.

"Fair" practice means that there will be some degree of restocking. But it will take "good" practice to build up an adequate growing stock. And to realize the maximum permanent values of forests will take practice of a high order.

The encouraging advances in good practice by industrial forest owners will not alone solve the problem of future national timber supply. Corporate and other large holdings represent only 15 percent of the

total commercial forest acreage in private ownership. The other 85 percent is in medium-sized or small holdings; 40 percent is in farms.

It is on these forest lands in small tracts that the largest percentage of poor cutting prevails.

Can Output be Sustained Without Detriment to Future Crops?

It will take real effort over a long period to put our forests in condition to grow as much as we are likely to need for the future. Meanwhile, we face several decades of limited supply.

Because of growing-stock shortages, it seems unlikely that the eastern regions can ward off for more than a few years a substantial decline of saw timber cut below present levels. We shall have to draw heavily on the West, therefore, to hold up our national timber output during the years it will take to rebuild eastern growing stocks. But we must guard against unnecessary local depletion which will not only work hardship on the communities concerned, but will also increase the pressure on other regions. Light partial cutting should be applied wherever it can be used to obtain more saw-timber growth without waiting for new stands to grow from seed. With new access roads and utilization of less-favored species, some sections of the West may be able to increase output somewhat for three or four decades. However, after the remaining virgin stands have been worked over, output may be expected to drop even below present levels.

In all parts of the country crowded young stands should be thinned to obtain faster growth, and premature stripping of young timber should be prevented. By these and other measures to build up an adequate and well-balanced growing stock we can lessen the difficulties of a period of restricted supply and eventually achieve our long-term goal of timber abundance.

If we fail to do this, the period of inadequate supply will be prolonged indefinitely.

The Role of National Forests

The national forests include 73 million acres (29 million hectares) capable of growing commercial timber crops. They contain one-third of the national sawtimber stand. They are being managed for continuous timber production. In recent years they have supplied about 10 percent of the nation's yearly lumber cut. With careful management of their timber resources, the national forests can help to cushion the shock of private timber exhaustion in many areas, and save many mill operations from shut-down. Eventually their total sustained-yield output of timber can be more than doubled.

New roads now under construction or planned will provide a means of reaching inaccessible timber stands in the national forests.

For the long pull, the national forests can do a special service in production of high-quality material. The long period needed to grow trees big enough to make large timbers or certain specialty materials discourages many private owners. Such trees must be held many years, during which they bring in no returns to the owner. Public forests administered under long-term programs might well assume a substantial part of the country's future production of high quality material. Special emphasis should be placed on producing timber of large size and high grade.

The Future Holds A Promise for Forestry

We must plan for a liberal use of timber in an economy of full employment. Unless we visualize a static America, there is no place in our thinking for any plan based on how little we might get along with.

How much timber is our nation likely to need in the future? As a part of its reappraisal of the forest situation, the Forest Service has endeavored to estimate how much we would be likely to use if we maintain a high level of employment and if suitable timber products are available in ample quantities at reasonable prices.

All told, it looks as though we should strive to build up the growth rate of our forests to something like 20,000 million cubic feet (566 million m^3) a year. Of this, some 65,000 to 72,000 million board feet (294 to 326 million m^3) should be saw timber. This estimate would provide a safe margin for security, for new and unforeseen uses, and for unavoidable losses, with a reasonable allowance for exports. It would also allow for what might be termed "ineffective growth," such as timber growth in scenic and recreation areas, roadside strips, and other areas that we shall wish to reserve from cutting or where harvesting will be economically impracticable.

No one, of course, can say just how much timber we are going to need 50 or 100 years hence. Development of atomic energy and other scientific advances may bring radical changes in our way of living. But such a versatile and useful raw material as wood—and a material that can be grown in continuing supply—should certainly have an important place. Although the assumptions on which the above estimate has been based are unlikely to be wholly realized for many years, particularly because of short supply, there seems to be no reason to believe that potential requirements for wood will be any lower.

Today nearly 90 percent of our timber supply comes from privately owned forest lands. In general, the private forest lands are the most accessible and potentially the most productive. We must continue to look to private forests for the bulk of our timber supply in the future.

Before the war, the lumber industry had little trouble producing as much as consumers demanded. There was enough accessible standing timber and enough mill capacity to turn out even more. Now the situation has changed. It is not likely that the industry will again be able to meet consumer demands in full for years to come. The outlook of a strong demand for forest products should provide a strong incentive for long-term investment in timber growing and permanent forestry operations. Private financing of timber-growing projects should be easier.

In the Forest Service's Report for 1944, it was noted that publicity emanating from organizations representing the forest-products industries often tended to lull the public into a false feeling of complacency about our forests—to give the impression that all was well, that there would always be plenty of timber. It is encouraging to note that the program of the American Forest Products Industries, Inc.—a promotion-

al organization representing major forest-industry groups now places major emphasis on growing more trees. Its program calls for continuous growing of trees on every acre of land suited to that purpose, and for bringing the widest area possible under permanent forest management. Leaders in the forest industries realize that the timber supplies they will need in future years will have to be grown as a crop.

Designation of tree farms under sponsorship of forest-industry organizations continues. Started some five years ago in the Pacific Northwest, the tree-farm campaign has been extended to a number of states in the South and East. The owners are pledged to a program of timber growing. A trees-for-tomorrow campaign sponsored by pulp and paper companies in the Lake States is encouraging tree planting.

Many operators are doing a good job in utilization of timber formerly wasted. In the Pacific Northwest some companies are going over the land a second time to bring in small logs and chunks ordinarily left on the ground after logging. In some cases, small portable mills have been used in the woods to do a scavenger job on material left from earlier operations.

Some kinds of trees formerly ignored are now being utilized. Lodgepole pine, *Pinus contorta* Dougl., on the west coast, for example, is no longer considered an unmarketable tree; it is being cut for power poles, box shook, and lumber.

A large plant to make industrial alcohol from wood waste near Eugene, Oregon, is expected to be in operation before the end of 1946. There are plans for it to turn out high-protein stock feed as a by-product.

All these things indicate that it is now economically feasible to step up management plans and practices well beyond what was considered feasible either on industry or public forest lands before the war.

We must, of course, be continually on guard against the pressure to overcut the forests. Heavy demand may increase the tendency of some operators to liquidate their timber at a rate and in a manner which will undermine future production.

Key to a Permanent Timber Supply

A realistic, comprehensive, and progressive forest-conservation program must aim at keeping our forest lands productive, building up our growing stock of timber, and making the one-third of our country that is forest land contribute its full share to the prosperity, security, and well-being of the American people. What will it take?

More protection.—Where organized, intensive fire protection has been applied, it has amply demonstrated that forest-fire losses can be greatly reduced. Yet 136 million acres (55 million hectares) of forest land in the United States of America still lack any organized protection whatever. And fire control forces and facilities in most of the protected areas fall short of the needs.

We have no way of stopping lightning from starting fires. But 90 percent of the forest fires are started by man, largely through thoughtlessness, ignorance, or carelessness. Ninety percent of our forest fires therefore can be prevented, if and when every citizen can be made to realize the values at stake and the necessity for his individual co-operation.

Fig. 3. What unfortunately happens—clear cutting of private woodland in Oregon

Science has developed methods of combating some of the most destructive forest insects and diseases—the white pine blister rust and the pine bark beetle, *Ips pini,* for example. Research is giving promising leads to the control of others. But our combat forces out on the front line in the war against the pests and parasites of forest trees are far from adequate.

The drain on our forests caused by losses from fire, insects, and diseases is pure waste. It should be reduced to a minimum.

More planting.—We are carrying millions of acres of good potential timber-growing land as dead weight. This is land which repeated fires or destructive cutting have reduced to a status of virtual non-productivity. Some of the poorly stocked or deforested land may some day come back to a fair degree of productivity by natural means. For much of it, the best way to restore the land to usefulness in any reasonable time will be to plant trees. We need to step up our planning program tremendously, for a full-scale attack on the huge reforestation problem.

Fig. 4. The aftermath—logged over, burned over area in Pennsylvania

Less waste. — Less than half of the wood volume in the average tree cut now goes into usable products. Tops and limbs trimmed from felled trees, broken trunks, and cull logs are left in the woods. More waste occurs through the various steps of manufacture to the finished product. Many species of trees are not harvested because they are poorly suited in form or properties to present uses or present manufacturing methods. We need intensified research and experiment to develop methods for profitable utilization of these wasted materials. We need to encourage better integration of wood-using industries so that one plant will use the waste of another. Reduction in waste, more complete utilization of the forest crop, can help to stretch out our short timber supply, to keep us going while we grow more and better timber for the years ahead.

Better forest practices.—Only 8 percent of all private forest lands are receiving good management. On nearly two-thirds, cutting practice is poor to destructive. The general level of forest practice will have to be raised materially if we are to stop the downward trend of our forest resource and start growing more timber for the future.

We must put a stop to destructive practices. We must encourage wider adoption of really good management practices. Technical foresters have developed proved methods of managing forest lands for continuous production. The technical know-how must be carried out into the woods.

A Forest-Conservation Program

These are the things we need to put our ailing forest resource on the road to recovery—more protection, more planting, less waste, better forest practices. We can get these things only by positive and aggressive action on a national scale. Here are the measures which the Forest Service believes are essential to an adequate program of forest conservation.

Regulation of cutting practices.—For several years, the Forest Service has advocated that the public exercise some measure of control over timber cutting and related practices. Some commentators have seen in this proposal a move toward extreme regimentation, socialism, or dictatorship. Actually, the proposal visualizes only those requirements sufficient to prevent the use of destructive cutting practices and to make sure that forest land will be kept in condition to continue growing reasonably full crops of timber. Such regulation should encourage and stimulate progress toward sustained-yield forest management.

The Forest Service has suggested that the regulatory program might well be administered by the individual states, with Federal financial assistance, and in line with basic standards set up by national legislation. There should be provision for direct Federal administration, however, in the states which fail to take appropriate action within a reasonable time.

The Forest Service feels strongly that such a measure is necessary if we are to prevent premature logging of young stands and further deterioration of the timber-growing capacity of our forest lands.

Opposition to public regulation of cutting practices has come mainly from forest-industry organizations. It seems obvious, however, that the proposal fits industry needs today. Many industrial owners already have adopted good practice. Those operators who still use poor or destructive methods would be required to improve their practices. Competition would thus be on a more even plane. Also, relatively few forest-industry concerns have enough timberland of their own to supply all their needs. Many buy all or most of their timber from farmers and other small owners. By raising the general level of forest-management practices, regulation would help to safeguard their raw-material supplies.

Aids to encourage better management on private lands.—To make sure we have the best answers to the many problems of forest management, protection, and utilization and to find the answers to problems yet unsolved we should have an expanded program of technical research. Through research we can find even better and faster ways of growing timber. We can find ways to reduce waste and make the timber cut go farther.

The technical information developed through research should speedily reach the owners who can put it into practice. At the present time the Forest Service is co-operating with state agencies in providing about 150 trained foresters to help farm-woodland owners. Although spread thin through 600 counties, these foresters are helping many a farmer to realize better returns from his timber while at the same time keeping his woodland in better productive condition. But such direct, on-the-ground service should be made available for 3¼ million farm-woodland owners in more than 2,000 forest counties. Similar service should be provided for almost a million small nonfarm owners of forest land who thus far have received little help. In addition, technical assistance and advice based on forest-products-research findings and other up-to-date information should be made available to small processing plants and to consumers to help them make better use of wood products.

We should encourage more forest planting on private lands. Under the Clarke-McNary law of 1924 Federal aid is now given to the states in growing and distributing tree nursery stock at low cost. Only farmers can now receive planting stock under this program. Authority for such aid should be broadened to include other forest landowners. The present $100 000 annual authorization for the work is far too small for any real attack on our reforestation job.

Development of co-operative associations of small forest owners also should be encouraged. Individually, small owners are short on bargaining power in marketing their forest products and on equipment and facilities for the most efficient management of their timberlands. Establishment of co-operative associations could be aided by legislation authorizing special studies in this field and loans as needed to carry the co-operatives through the pioneering stage.

Private owners usually have had little trouble financing an operation to liquidate grown timber, but credit facilities for long-term timber growing are often lacking. The Forest Service and the Farm Credit Administration have given the question much study. With cash so plentiful today, demand for forest credit is probably at low ebb. However, in the long view, it is believed that adequate credit facilities, especially for small owners, will be an important aid to forest conservation. Establishment of a federally sponsored forest-credit system to make long-term loans available on reasonable terms and on conditions adapted to the needs of private forest operators is recommended. Such loans should by all means be conditioned upon sound forest practice.

Forest owners also are generally unable to get insurance on growing timber. The Forest Service feels that forest insurance should be brought within the economic reach of the average owner. One means might be through expanding the authority of the Federal Crop Insurance Corporation.

There is still need for improvement in forest taxation. In some states property owners feel that the present tax system militates against timber growing and adds to the pressure for quick liquidation. Inheritance taxes often have similar effect. The Forest Service stands ready to advise with states and agencies in their efforts to improve forest tax laws and their administration.

Private forest lands need more and better fire protection. The work on areas now covered should be brought up to par, and protection should be extended to the 136 million acres (55 million hectares) still unprotected.

More effective protection against forest insects and

Fig. 5. Repairing erosion damage in Ohio

diseases is essential. The Bureau of Entomology and Plant Quarantine and the Forest Service have recommended new legislation which will declare the Federal responsibility in nation-wide protection and provide prompt and adequate action to combat outbreaks of destructive pests and parasites. It will provide for state and private participation under flexible arrangements suited to varying circumstances.

More public forests.—The foregoing are measures that will help to encourage private enterprise in timber growing. They should go far toward raising the level of forestry practice on private lands.

There are a great many areas, however, that would best be in public ownership, managed and protected as national, state, and community forests. That is the only practical way to assure stable ownership and satisfactory management for those lands which are obviously not suited or destined for successful permanent private development, and for certain key areas where public values are of high importance.

Public ownership is the logical answer for certain areas in regions of scanty rainfall, poor soils, or extreme inaccessibility, where the prospective returns will be too small to offer much incentive for private development; also for certain forest lands that have so deteriorated that they offer no prospect of income for many decades.

For certain other areas, where there are acute problems of watershed protection or other needs vitally affecting the welfare of dependent communities, public ownership also will be desirable.

Forest restoration and improvement—There would be little point in establishing public forests if we failed to develop their full potentialities. On national forests already established, 3¼ million acres (1.3 million hectares) of partly or wholly denuded land need to be brought back into production by planting. Much improvement work—thinning, pruning, etc.—needs to be done in young stands to speed the growth of usable timber and better its qualities. New forest roads must be built and old ones improved to facilitate use of the forests and give access to undeveloped areas. We need improved facilities for fire protection and reduction of fire hazards and additional administrative facilities.

To realize the full values of our national forests under multiple-purpose management, improvement work is needed in other lines in addition to that calculated to increase growth of timber and facilitate its harvest. Within the national forests are range lands which play an important part in the nation's production of meat, wool, and leather. Reseeding and other improvements are needed to increase the livestock-carrying capacity of these lands. More facilities are needed to meet the increasing numbers of recreationists. Upstream work is needed to reduce floods. On state and private forest lands, an even larger amount of similar work is needed.

All such work for the rehabilitation and development of our forests is capital-improvement work—an investment that will pay back in increased yields of commodities or service. We are now engaged in a vigorous program of road construction to open up untouched timber for early operation. Range reseeding and other urgent projects are also being attacked currently. The work program could be greatly augmented when needed to help avoid or relieve unemployment. But the needs are so great that a forest-improvement program should not be deferred until we face acute unemployment conditions. A substantial program should be in operation at all times.

Timber Abundance Can be Achieved

An abundant timber supply is essential if the United States of America is to maintain its place as a strong, progressive nation. Wood was a vital necessity in conducting the war; it is just as important to our progress and security in peace. Producing forests are the source of thousands of needed commodities. Producing forests mean jobs. They have an important part to play in maintaining the high level of industrial activity upon which full employment depends.

Our nation's forest lands can eventually be made to furnish in perpetuity all the forest products we are likely to need, and even help in some measure to supply the needs of other countries less fortunate. But it will take some real doing. The downward trend of our forest resource must be reversed. The scars of past misuse must be healed. We should aim to double our annual saw-timber growth.

And the time for a real, all-out attack on these jobs is now. Prompt action is needed to minimize the pinch of timber shortage in the years immediately ahead and assure abundant supplies of timber for the more distant future.

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Fig. 1. Mt. Pilot in Banff National Park, Alberta

Forest and Forest Products Research in Canada

By D. ROY CAMERON
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SCARCITY, or the threat of scarcity, is a great stimulus to research, and it is not surprising that Canada, with a historic surplus of forests up to fairly recent years, should show belated progress in forestry and forest products research. Developments in this country have been along four major lines, e.g., silviculture, protection, aerial surveys, and forest products research.

Silvicultural Research

The beginning of organized silvicultural research in Canada may be dated from 1918 when a Silvicultural Research division was set up in the then Forestry Branch of the Department of the Interior, and the first forest experiment station was established. In the intervening thirty years this division has carried out many investigations both on forest experiment stations and on provincial lands and industrial holdings. Information of great value respecting cutting methods, regeneration, and rates of growth has been published from time to time.

During World War II the staff of the Silvicultural Research division was greatly affected by enlistments in the armed forces, and research programs were reduced to care and maintenance. However, timber disposal operations on forest experiment stations, conducted with internees, prisoners-of-war, and conscientious objectors, not only improved timber stands but made creditable contributions to the war effort.

Since the war, the return of experienced staff, recruitment of additional trained foresters, and provision of larger appropriations has enabled a considerable expansion of silvicultural research in the Dominion Forest Service. The main items on the program are:

a) Forest mensuration which involves the measurement of trees, stands, and forest products. This includes the development of standard volume and yield tables for use in timber estimating in various parts of Canada; the study of converting factors between different units of measurement of timber; analysis of log scales and investigations with a view to standardization thereof.

b) Preparation of scientific forest working plans for application to areas which are to be brought under intensive forest management.

c) Cultural treatment of stands by thinning and pruning to improve volume and quality production.

d) Development of silvicultural cutting methods to secure natural regeneration.

e) Studies in tree-breeding and vegetative propagation of promising individual or hybrid tree species.

f) Studies in the technique of reforesting devastated land having regard to the most suitable species adaptable to the various sites.

g) Studies to determine the suitability of exotic tree species to Canadian conditions.

The greater part of the above projects are undertaken at five forest experiment stations, selected on the basis of representing conditions in the forest regions in which they are located. They are as follows:

Acadia Forest Experiment Station.—This area is suited to a study of the softwood types occurring in the Maritime Provinces. The principal species studied are white and red spruce, *Picea glauca* (Moench) Voss and *Picea rubens* Sarg, growing in both softwood and mixedwood types. The experimental area contains 38 square miles (98 km^2) and lies 15 miles (24 km.) northeast of Fredericton, New Brunswick.

Valcartier Forest Experiment Station.—This station is representative of the mixed hardwood types, and to some extent, the spruce type, in the Province of Quebec. It is 7½ square miles (19.4 km^2) in area and located some 17 miles (27 km.) north of Quebec City.

Petawawa Forest Experiment Station.—This station serves for investigation of problems associated with the management of the pine and hardwood types in eastern Canada. The area of approximately 100 square miles (259 km^2) comprises part of the Petawawa Military Camp. It is located northeast of Pembroke, Ontario.

Riding Mountain Forest Experiment Station.—This station is representative of the aspen-grove and mixedwood belts in which white spruce and aspen are predominant. The area of 25 square miles (65 km^2) comprises part of the Riding Mountain National Park, located in the western part of the Province of Manitoba.

Kananaskis Forest Experiment Station.—This station affords an opportunity for the study of lodgepole pine, *Pinus contorta* Dougl., in association with spruce, one of the most important timber types found in the Rocky Mountain region. This area of approximately 63 square miles (163 km^2) lies wholly within the Kananaskis Valley, with headquarters about 62 miles (100 km.) west of the city of Calgary, Alberta.

Recent special projects include: the Green River Experiment in New Brunswick, a co-operative study of possibility of reducing spruce budworm, *Cacoecia fumiferana*, damage by special attention to forest sanitation in management plans; resumption of rate-of-growth surveys interrupted in 1930; and inauguration of a broad series of regeneration studies to find out what is happening on cut-over and burned-over lands.

Plans for 1947 provide for seven rates of growth and six regeneration parties. These will involve employment of over 100 forestry students during the summer months.

The National Research Council also enters into the Canadian silvicultural research picture. As far back as 1923, the Council financed special studies in reseeding of cut-over areas in New Brunswick. The Council convened a research conference at the Petawawa Forest Experiment Station in 1935, as a result of which the Associate Committee on Forestry of the Council (broadly representative of governments, universities, and industry) was established the following year.

In 1937 the Committee arranged for experiments in the use of hormones in tree-breeding studies. The following year a Forest Tree Breeding Subcommittee was established to conduct researches through co-operation between the National Research Council, the Dominion Forest Service, and the Tree Planting Division of the Dominion Department of Agriculture. Work under this committee is largely centralized at the Petawawa Forest Experiment Station, with certain experiments conducted at the Dominion Forest Nursery Stations in Saskatchewan. The most important studies are development of white pine, *Pinus strobus* L., resistant to blister rust, and hardy fast-growing poplars for tree planting on the western prairies. In 1939 the Associate Committee on Forestry secured a grant from the Council to finance a two-year investigation of regeneration of white pine in the Algonquin Park and Ottawa Valley regions of Ontario.

Another special development occurred in 1943 when the Advisory Committee on Reconstruction, through its Subcommittee on the Conservation and Development of Natural Resources, undertook a special land use investigation of the Ganaraska watershed in Ontario. This study included the role of forestry in flood control and in the rehabilitation of a badly run-down local economy.

To date, the forestry departments of Canadian universities, as such, have devoted little attention to silvicultural research. Demonstration of cutting methods, planting techniques, etc., have been made on school forests and sample plots have been established. Graduate students have been few in number, and theses presented for degrees have not made significant contributions to silvicultural knowledge. The few that have been written have not been published.

While the greater part of the silvicultural research in Canada has been carried on by the Dominion Government, there are certain phases undertaken under provincial and industrial auspices. Of these the most consistent effort has been in British Columbia. A review of the history of forest research work in that province shows that the first attempts at detailed study of the many complex factors governing tree growth took the form of spasmodic investigations by various officers attached to the staffs of the District Foresters. The pressure of routine duties and a lack of direction, militated against any very tangible results from these efforts, but in 1920 a forester attached to the Victoria staff initiated some growth studies, and organized research work has continued uninterrupted since that date.

In 1927 the staff employed and the work in hand justified the organization of a small research division. Two experiment stations were established, one at Aleza Lake in the spruce-balsam, *Abies balsamea* (L.) Miller, type of the North-Central Interior, and the other at Cowichan Lake in the Douglas fir type, *Pseudotsuga taxifolia* Britt., as central points from which studies could be conducted in these two important forest regions. As suitable personnel became available, the staff was increased and the scope of the program of study expanded. Finally, in 1939 the Research and Forest Survey Divisions were amalgamated, thereby improving supervision and eliminating possible duplication of effort. At the present time the forest research program is carried out by the Mensuration, Silvicultural, and Soils Sections of the Economics Division.

Considerable work has been concentrated at the experiment stations, but, in addition, observations are maintained on 606 sample plots scattered over the Province. Investigations include silvics, stand treatments, mensuration, soils, growth, yield, and regeneration. For the latter there are 2,380 mil-acre (4.047 m^2) plots on four representative areas. In addition, insect and disease studies are carried on in co-operation with the Dominion Department of Agriculture.

In Ontario the Forestry Branch started growth and yield studies on a small scale in 1920, and these were carried on sporadically until the onset of the depression in 1930. The work was resumed in 1941, and lately has been organized under a Research Division

Fig. 2. Nursery at the Petawawa Experiment Station

of the Department of Lands and Forests. Principal investigations concern regeneration in spruce-balsam, *Abies balsamea* (L.) Miller, *Picea glauca,* (Moench) Voss and *Picea mariana* (Mill) B.S.P., pulpwood types, and in white and red pine, *Pinus strobus* L. and *Pinus resinosa* Ait. Ontario has for many years undertaken reforestation on a large scale and possesses three large and well-organized tree nurseries. Seeding and planting studies have been conducted at these stations in efforts to improve artificial reforestation techniques.

The Quebec Forest Service has also an important nursery station and has conducted similar seeding and planting investigations. The school forest attached to the forest ranger school at Duchesnay has afforded opportunity for silvicultural experiments, principally intermediate cuttings in spruce-balsam stands. Quebec is further advanced than any other province in its requirement that industry must file working plans for timber holdings on provincial

Crown lands. In connection with these working plans, permanent sample plots are established and should produce valuable growth and yield information. The Quebec Forest Service research staff, while small in number, has made some important studies, particularly in site classification. Mention should also be made of interesting investigations in distribution of tree species and forest ecology carried out by professors of the University of Montreal.

The Woodlands Section of the Canadian Pulp and Paper Association is a recent entry into the silvicultural research field. Its program is cleared through the Pulp and Paper Research Institute of Canada, an organization which will be described in some detail under "Forest Products Research." The Forester-Manager of the section serves as Director of Woodland Research of the Institute, and funds for special cut-over land regeneration studies are made available by the Institute.

Forest Protection Research

Fire.—Intensive study of the relationship between weather and forest inflammability was started by the Dominion Forest Service in 1929. A system of measurement of fire danger was developed and fire danger ratings compiled. By 1939 these were in practical use in three provinces and in the national parks in western Canada.

The measurement of fire danger depends fundamentally on two relationships:

a) The relation between fire behavior and the moisture content of the "critical" fuels or materials in which fires usually start and spread.

Fig. 3. Testing fire pumps

b) The relation between fuel moisture content and the weather elements which control it.

Once these basic relationships have been determined experimentally for the principal fuel types of a region, and expressed by means of suitable tables, an estimate of the prevailing degree of fire danger may be obtained by daily observation of the appropriate weather factors only.

A Forest Protection Division of the Dominion Forest Service is responsible for these research activities. Staff rotates between head office in the winter and field duties during the fire season. This division also investigates the use of chemicals and develops test procedures for forestry equipment.

Entomology.—Forest entomological research is a responsibility of the Dominion Department of Agriculture, operating through a Forest Insects Unit of the Science Service.

Investigations are carried on through laboratories in New Brunswick, Ontario, Manitoba, Saskatchewan, and British Columbia. In Ontario the studies at the moment involve investigation of the ecology of forest insects and the control of spruce budworm, sawflies attacking coniferous trees, and insects attacking shade trees, and investigations to determine the value of insecticides sprayed from airplanes in the control of forest insects. In New Brunswick the studies are particularly concerned with forest management in the control of the spruce budworm, the bronze borer, *Agrilus anxius,* and the beech coccus, *Cryptococcus fagi* Baer, and of forest insects by diseases. In Manitoba, the studies are primarily concerned with the spruce budworm, and the rate of deterioration of timber killed by fire and insects and the possibility of its salvage in merchantable condition. In Saskatchewan study is especially concerned with the protection of prairie windbreaks and shade trees from insect attack. In British Columbia the more important studies involve the control of pine bark beetles, wood borers, and insects defoliating coniferous trees both in the interior and coastal regions.

In addition to the study of particular insects, one of the most important activities of this unit consists in carrying on the Forest Insect Survey through which, with the co-operation of all official forestry services and the forest protection services of the lumber industry, a very careful appraisal of the insect conditions is maintained and published annually in the form of a report for the information of the forest industries, the forest protection services, and entomologists, in forecasting the probable location and extent of forest insect outbreaks.

The survey determines the danger of insect outbreaks through continuous collection of specimens by the field officers of co-operating organizations. Trained forest insect rangers employed by the Dominion Department of Agriculture give instruction and supervision. Insects are forwarded to Dominion Insect Laboratories in special containers provided by the Department. Here they are classified and the necessary statistical records compiled. By this means, variations in insect populations can be noted and their significance assessed.

Loss and damage through forest insect attacks, principally the spruce budworm, have been mounting at an alarming rate during the past few years. The serious concern felt by Dominion and provincial governments and by industry led to joint action in 1945. A Forest Insects Control Board was established by the Dominion, with Dominion, provincial, and industry representation. The functions of the board are to coordinate efforts and devise a cohesive general program seeking expanded activities by all co-operating authorities, which, however, retain complete autonomy in operations.

While Ontario has made a handsome contribution in the erection of a forest insects laboratory to house Dominion research personnel, Quebec is the only province that has made any serious consistent effort at actual research in this field. A Bureau of Entomology in the Forest Service of the Department of Lands and Forests has a well-equipped laboratory at the Forest

Ranger School at Duchesnay and conducts field studies on insect problems. Some of the more important of these are biology of the spruce budworm, birch bronze borer, insect vectors of the Dutch elm disease, and DDT spraying technique. The Bureau co-operates closely with the Dominion authorities. While it assumes responsibility for the insect survey in the province, all collections are shipped to Dominion laboratories.

Pathology.—Research in this field is also a function of the Dominion Department of Agriculture. The Division of Botany and Plant Pathology of the Science Service of that department has a small section dealing with forest pathology. Staff, funds, and program are on a much smaller scale than in the comparable field of forest entomology. Problems studied have included the deterioration of fire- and insect-killed trees, white pine blister rust, rusts of poplars, and root and heart rots in spruce and balsam. A summer laboratory, maintained at the Petawawa Forest Experiment Station, co-operates in hybrid resistance studies and related factors in tree breeding experiments.

As is the case in forest entomology, Quebec is the only province that has established its own organization for pathological research. Following some years of investigation of individual projects by the Quebec Forest Service, a separate division of Forest Pathology was established in 1938. A laboratory has been set up at Duchesnay and officers of the division conduct field studies throughout the province. Work includes butt and heart rots of conifers, nursery and plantation diseases, white pine blister rust, rate of decay of fire-killed timber, and other problems of economic importance. The occurrence of the Dutch elm disease in Canada was first discovered by the Quebec division of forest pathology. In all its efforts this division works in close collaboration with its Dominion counterpart.

Aerial Surveys Research

Recognizing the potentialities of air photographs in the forestry field, studies and investigations were initiated by the Dominion Forest Service in 1929 which have led to the development of techniques, methods, and highly specialized instruments which have been widely adopted as standards. These developments have proved to have extensive practical application in the preparation of forest inventories, in management, and in forest protection planning. The Service is continuing and expanding its investigations in this field.

The work is organized under an Aerial Surveys Division at Ottawa, divided into two sections, *viz.*, forest mapping and research. The research section solves problems encountered in mapping and devises new techniques for reducing labor and increasing efficiency. Special test projects to perfect new techniques are conducted in co-operation with the Roval Canadian Air Force, the Topographical Surveys Division of the Department of Mines and Resources, the National Research Council, and other government agencies. Two instruments have been originated, namely, the duoscope and the monoscope, for the transfer of detail from the photograph to the map, and are being employed successfully. From experimental modifications of these instruments, the first working model of the multiscope, which later underwent considerable development at the Harvard Forest, Petersham, Massachusetts. was constructed.

One of the most important advances achieved is the development of methods of estimating, volumetrically, standing timber from air photographs. The technique employs the height of the tree, supplemented in most cases by crown data, in place of the usual ground method of measuring diameter at breast height. The comprehensive view provided by the air photograph enables measurements to be made over a greater area of forest, and with less effort, as compared to the previous laborious and expensive method of ground cruising.

Together with the development of a technique of volumetric estimating, the shadow method of determining tree heights from air photographs has been developed, and grids have been devised for measuring tree heights in oblique photographs. The displacement method, whereby the image of the tree is measured on a single vertical photograph, is also important. These methods in most cases render it unnecessary to apply the parallax method of obtaining tree heights, though the stereoscope is used to correlate the easily measurable trees with the rest of the stand, and also to make slope corrections in the case of the shadow method.

Forest Products Research

Canada is one of the great timber-producing countries of the world and its production of manufactured wood products is greatly in excess of the domestic requirements. The surplus is exported and constitutes one of the main items in Canada's favorable balance of trade. For these highly competitive world markets, research is essential to ensure continuity of cheap raw material supplies and for the efficient manufacture of the forest products.

Since 1913, forest products research in Canada has been a federal function as is the case in other countries, such as the United States of America, United Kingdom, Australia, New Zealand, South Africa, and India. The chief agency for this research in Canada is the Forest Products Laboratories, a unit of the Dominion Forest Service.

The function of the Laboratories is to obtain scientific and technical information on forest products in order to promote the wider and more efficient use of wood. This includes devising means of reducing or utilizing to better advantage the "wood waste" that occurs in the conversion of the standing tree into the finished product; developing uses for species now left in the wood; improving manufacturing techniques, with a view to cost reduction; preparing timber specifications for building codes and engineering standards; increasing the serviceability of wood and developing new products by chemical methods; and studying means of broadening markets for wood and ensuring its satisfactory use by the consumer.

Organization of the Laboratories

The Forest Products Laboratories were established in Canada in 1913 at Montreal, in co-operation with McGill University, as a part of the Forest Service of the then Department of the Interior. Since that date, the Laboratories have expanded and the work is now carried out in three locations: the main laboratories in Ottawa; the Vancouver Laboratory in Vancouver, British Columbia, and as part of the Pulp and Paper Research Institute of Canada, in Montreal, Quebec.

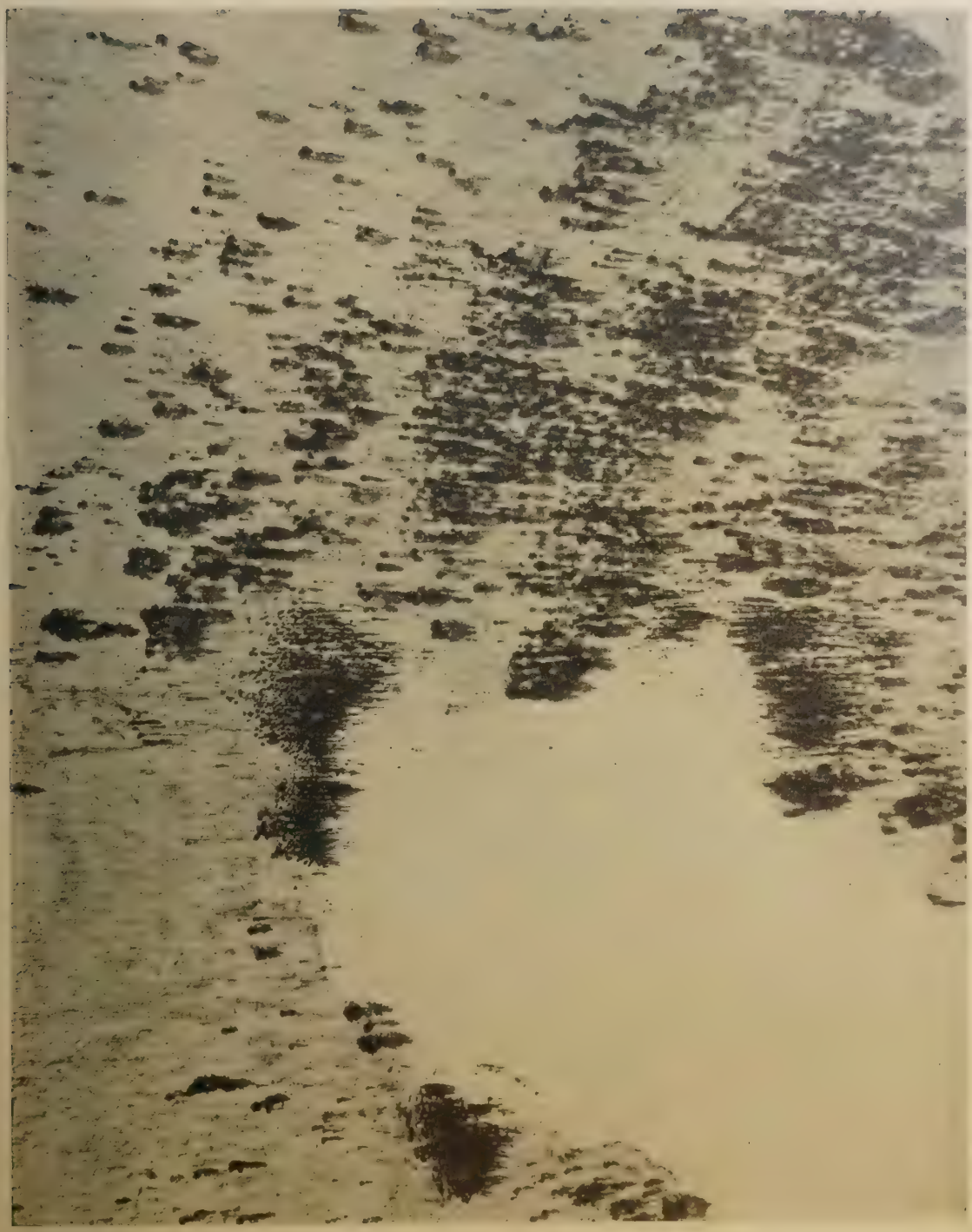

Fig. 4. Aerial photography in winter at Petawawa Experiment Station

a) *Vancouver Laboratory.*—The Vancouver Laboratory was established in 1918 on the site of the University of British Columbia, where it is still located. Its main function is to look after the special problems of the British Columbia timber industry. The present work of the Vancouver Laboratory includes research on the following: mechanical and physical properties of British Columbia woods and their application to the structural uses of timber; the use of British Columbia species for poles and piling; wood rotting organisms and their identification and control; air seasoning and kiln drying of British Columbia lumber and other wood products; logging and mill waste, its volume and utilization; and the effect of log size and grade on lumber manufacture in British Columbia.

The facilities of the Vancouver Laboratory are being extended.

b) *Pulp and paper, Montreal.*—The pulp and paper research of the Laboratories is carried out in Montreal, as part of the Pulp and Paper Research Institute which is operated by a Joint Administrative Committee consisting of members of the Dominion Government, the Canadian Pulp and Paper Association, and McGill University. The Institute, in addition to carrying out research investigations, provides an information and special testing service to the Pulp and Paper Industry. The Institute is financed jointly by the three organizations concerned.

c) *Main Laboratories, Ottawa.*—The main laboratories were moved in 1927 to Ottawa. Their research work is dealt with by the following divisions:

i) Timber Mechanics.—Concerned mainly with the mechanical and physical properties of Canadian woods (other than those tested in the Vancouver Laboratory), the structural properties and applications of timber, the fabrication and use of plywoods, and the design and standardization of shipping containers for domestic and export markets.

ii) Wood Preservation.—Concerned mainly with the treatment of railway ties, poles, piling, and other exposed timber, with chemical preservatives to protect the wood from decay, insects, marine organisms, and fire.

iii) Wood Chemistry.—Concerned mainly with the chemical composition of the various Canadian woods and their utilization in the manufacture of chemical products—with special attention paid to the utilization of bark, logging waste, and sawmill waste by various methods, such as the conversion of carbohydrates to sugar and by the manufacture of building boards.

iv) Wood Utilization.—Concerned mainly with studies on the manufacture of the tree into lumber, veneer, pulpwood, furniture, and other wooden articles, in order to develop manufacturing practices which will permit closer utilization and find uses for material now wasted.

v) Lumber Seasoning.—Concerned mainly with studies of various aspects of the kiln drying, air seasoning, and storage of lumber and other wood products in order to improve the efficiency of these processes and reduce seasoning losses.

vi) Timber Pathology.—Concerned mainly with problems in connection with decay, stain and mold in wood—their identification and control.

vii) Timber Physics.—Concerned mainly with special investigations in which wood structure is a primary consideration.

viii) Dielectric Heating.—Concerned with the application of radio frequency dielectric heating to the wood-using industries.

Technical service to industry.—An important function of the Laboratories is the answering of technical inquiries from the wood-manufacturing and the wood-using industries. In dealing with these, the Laboratories use data obtained from their own researches, supplemented by information from other sources (especially from forest products laboratories in other countries) available in the very complete reference libraries of the Laboratories.

In 1940 the Province of Quebec established a forest products research organization. A small laboratory is operated at the Forest Ranger School at Duchesnay, and the facilities of the chemical laboratories of the University of Laval are also utilized. The objective is to service Quebec wood-using industries, particularly small ones. An information service is maintained, and problems requiring experimental work are submitted to the laboratory staff. A certain amount of fundamental work in wood chemistry and utilization is under way. Other studies include preservative penetration characteristics of Quebec woods, compregnation, and utilization problems of bark and sawdust.

Wartime demands for increased production and tax relief for research purposes, greatly stimulated research activities in the pulp and paper industry. Today most of the companies have their own laboratories and the sum total of research completed has reached an impressive volume. However, little has been published. The results have been retained in the main for the benefit of the individual company operating each laboratory. In some cases, companies have sought solutions of special problems through co-operative arrangements with institutions such as the Ontario Research Foundation.

Conclusion

The information presented in this review indicates that Canada has made some real progress in forestry and forest products research; compared, however, to the vastness of her forest estate and the economic importance of the problems awaiting solution, it is evident that the surface has just been scratched.

Canada's forestry problems transcend provision of raw material supplies for industry. They go deeper than regulation of streamflow, conservation of tourist attractions, and protection of fur, fish, and game. They constitute a land-use problem of the first magnitude. Over 58 percent of the land area of the nine provinces is suitable primarily for wood crops. The national prosperity is thus dependent in large measure on the use made of the growth potentialities of these lands. There is evidence that both governments and industry recognize this fact. Signs point to a very considerable expansion of forest and forest products research in the near future.

Photographs accompanying this article are reproduced by courtesy of the following: Fig. 1—National Parks Bureau (Canada); Figs. 2 and 3—Dominion Forest Service; Fig. 4—Royal Canadian Air Force.

The Work of FAO

Division of Forestry and Forest Products

THE Constitution of the Food and Agriculture Organization of the United Nations specifies that the activities of this international body include forestry and forest products.

The reasons are self-evident. The forest supplies man directly, and in the same way as the tilled soil, with indispensable commodities: firewood to heat his dwelling and to cook his food, timber to build his house and make his furniture. Indirectly, it supplies him with the numerous and varied wood products that contribute to his well-being and advance his way of life: paper, newspapers, fertilizers, plastics, alcohols, etc. Its presence alone exercises a direct influence on agricultural land in many parts of the world by affording protection against erosion, maintaining the balance of water reserves, ensuring stability, acting as a regulating factor of the climate, and sometimes even by supplying agriculture with the very soil on which it may sow its crops.

Two factors demanded particular care in the organization of a Division of Forestry and Forest Products: first, the scope and importance of the work devolving upon such a division set up within the framework of FAO's world-wide interests; second, the characteristics distinguishing forestry from other land uses.

How far has it been possible to complete the structure of the Division?

The name "Division of Forestry and Forest Products" itself outlines the Division's policy. It was considered fundamental not to perpetuate the error of arbitrarily laying down a dividing line between the forest and its products. The forest crop is an industrial crop that once cut is transformed into a great variety of products where technological properties, methods of utilization, and national and international trade specifications require specialized study and research. To consider these products by themselves would be as illogical as to consider grain production with no reference to plantings or to the varying properties of the soil. With the exception of those forests whose conservation is imperative for the protection of the soil, for purposes of research, or for their tourist value, the forest is essentially a wood producing unit and its treatment must be conditioned by the technological properties of its products for their industrial utilization. For these reasons the Division of Forestry and Forest Products consists of two branches that are quite distinct although they work closely together: the Forestry Branch and the Forest Products Branch.

The branches are linked at the top by the Director of the Division, Mr. MARCEL LELOUP, formerly Director General of Waters and Forests in France, Counsellor of State. He is responsible for the co-ordination of his Division's work and must answer for it to FAO's Director General, Sir John Boyd Orr, one of Britain's great scientists. Mr. Leloup represents the Division at international and regional congresses and in FAO's relations with official national and international organizations.

The Division has become closely knit by the spirit of teamwork the Director has brought to all levels of his Division. Steady teamwork is a determining factor not only in the work of each of the branches but also in their collaboration with the secretariat which includes the Section of Information and Education working immediately under the Director. The importance of this latter unit will be shown later. The feeling of working as a team in encouraged by the daily personal contacts of the officers responsible, the various sections of the Division's work and by the staff meetings frequently called by the Director in order to discuss important aspects of the Division's work or to consider and decide on the best means of implementing FAO's policies.

These policies are established by FAO's Conference which meets annually to outline the program for the whole organization. The Division of Forestry and Forest Products, however, needed a further consulting body to decide on the means of implementing these policies in a manner best suited to the conditions existing in the Division's field of work.

For this purpose a Standing Advisory Committee was set up. The members are well known specialists representing the various branches of forestry and wood utilization techniques; they also act as chairmen of the technical subcommittees. These subcommittees, in turn, are composed of specialists who are likewise asked to serve not as representatives of their countries but rather as eminently qualified experts in a particular field.

Five subcommittees have now been established. They are included in the listing of the Division of Forestry and Forest Products, which appears on the inside front cover of this issue. No limitation is set to their number so that if in future any particular question should arise that might require consultation with highly qualified specialists it will always be possible to create a further subcommittee to deal with it.

The Secretariat

The Director is to be aided by an Administrative Assistant as his personal assistant; the vacancy has not been filled yet. The secretariat, which comprises also the Section of Information and Education, is placed immediately under the Director's orders. The Chief of the Secretariat is Mr. JEAN VINZANT, formerly attached to the French Supply Council in Washington and a member of the Purchasing Commission for Wood and Forestry Equipment. He also was a member of the Technical Committee on Forestry and Primary Forest Products of the United Nations Interim Commission on Food and Agriculture.

Mr. Vinzant will be assisted in matters of forestry education by two technical officers who have not yet been appointed. Having in its charge the exchange of students and specialists among the various member nations, this office will play an important part in enabling countries that have lacked specialists in forestry and forest products to get the assistance they need. Its work will also afford opportunities for the dissemination of scientific and technical knowledge.

As head of the secretariat, Mr. Vinzant is in charge of office management and administration, liaison with other divisions of FAO, the general organization work of the conferences and meetings arranged by the Division or of organizing the participation of the Division at FAO and other international conferences.

Working with Mr. Vinzant is another technical officer, Mr. RADU C. FORTUNESCU, former Assistant Chief of Secretariat of the International Forestry Center and Senior Editor of that organization's publications. He has two technical assistants in charge of the various information and technical filing units for the whole Division. The library, a branch of FAO's main library, is a part of these units supplying the Division's work with source material in the form of books and periodicals. (Some 175 periodicals from all countries have so far been received.) Mr. Fortunescu is also responsible for the review UNASYLVA which constitutes one of the most important activities of FAO's Division of Forestry and Forest Products.

Forestry Branch

Of the two technical branches of the Division, the Forestry Branch is directed by a well-known American forester, Mr. S. BEVIER SHOW, former Regional Forester, California Region, United States Forest Service. His branch covers the whole field of forestry science and techniques. It comprises three sections:

Section 1 dealing with technical aspects is directed by Mr. TONY FRANCOIS, a former Conservator of Waters and Forests of France and a specialist in forest management and silvics. It is concerned with the scientific bases of forestry, with silviculture proper, and with forest management in the widest sense of the word. This wide-range variety of subjects is apportioned among four subsections with four technical officers who have not yet been appointed. The section's task will

be to gather the information upon which FAO's forest policy will be based by following research on the whole range of forestry problems; by conducting inquiries on questions that have not yet been completely elucidated; and by analyzing methods of management, of stock taking, and of forest management.

Section 2 deals with economic aspects and is headed by Mr. JACK D. B. HARRISON, former Chief of the Economics Division of the Dominion Forest Service of Canada. This section fulfills a similar task in the range of economic questions. Its work is particularly important since it will include cataloging the forestry resources of the various countries. It deals with questions of soil utilization, with the importance of forests as a protecting factor for agricultural lands, and with the influence of economic factors, such as the price of standing timber, labor costs, employment, taxation, insurance, etc., on the management and the conservation of forests. The section is likewise divided into four subsections. Only one of the technical officers for these subsections has been appointed—Mr. HANS SCAVENIUS, former Assistant Forester in the Danish Government Forestry Service.

Section 3 deals with forest policy and legislation. It is headed by Dr. D. Y. LIN, former Director of the Kwantung regional office of UNRRA and President of the Chinese Committee for Agriculture, Irrigation, and Reclamation Work on the Yellow River. The section will list and study from a critical point of view the various legislative systems devised to ensure proper protection and untilization of forests and will analyze general forest policies as well as structure and organization of the national forestry administrations. The importance of this section's work lies in the fact that based, naturally, on the work of the other two sections, its findings will determine what action the Division as a whole should undertake as a co-ordinating factor of the forest policies of the member nations in order to achieve a steady and adequate supply of wood and wood products for all nations without harming the forests as a constantly producing source of raw material. The section is likewise subdivided into four subsections. Of the technical officers required for the subsections, one only has been appointed, Dr. MAURICE HUBERMAN, former Forestry Expert with the Headquarters of the United States Occupation forces in Japan.

Forest Products Branch

The direction of the Forest Products Branch is entrusted to Mr. EGON GLESINGER, former Secretary General of the Comité International du Bois (CIB) and rapporteur of the Technical Committee on Forestry and Forest Products of the United Nations Interim Commission on Food and Agriculture. The work of this branch parallels in the field of forest products that of the Forestry Branch. It compiles world statistics for forest products, follows research in wood exploitation and utilization from raw material to finished products, and studies economic trends in marketing and the woodworking industries. Thus it is possible for FAO to guide its general policy in the light of these trends, and so exert its influence, if need be, in the general interest of the community of nations.

This branch is subdivided into two sections, the chiefs of which have not yet been appointed. Section 1 deals with Forest Products Technology and Section 2 with Woodworking Industries and Trade.

The character of Section 1's work is technical and scientific. Its five subsections deal on one hand with the organization and equipment of plants and on the other hand with various aspects of wood technology and utilization. The appointments to these subsections are not complete. However, Mr. ALAN GORDON, formerly a Senior Research Officer of the Division of Forest Products, Australian Council for Scientific and Industrial Research, has recently been put in charge of the subsection for Mechanical Wood Technology, and the subsection for Chemical Wood Technology has been entrusted to Mr. JORGE R. SUCCAR, former General Manager of the firm "Ingenieria Industrial S.A.," Consulting Engineers in Lima, Peru. Mr. NICOLAS DE FELSOVANYI, former Assistant Secretary General of the Comité International du Bois (CIB) and former Secretary of the Commission Internationale d'Utilisation du Bois, has been put in charge of the subsection dealing with the use of timber for construction work, assembling methods, and the utilization of firewood; he is further responsible for the organization of the technical subcommittees.

Section 2's main work is in the domain of industrial and commercial statistics. It will study trends and progress in the various fields of wood and forest products utilization in trade balances and marketing. Although the outline of its work is already definitely established, only three of the five subsections have been provided with officers. Mr. STEPHANE BAUER, former Assistant to the Director of the Swiss Forest Economy Association and former Forestry Counselor to the Director-General of State Forests in Poland, is entrusted with the compilation and analysis of statistics for saw timber, sawn goods, and industrial timber: pitprops, ties and piles. The same work for pulp and paper is carried out by Mr. JOSEPH P. KAGAN, former Chief of the Pulp and Paper Section, Requirements Division, United States Foreign Economic Administration.

Mr. LESLIE VERNELL, former Deputy-Conservator of the Burma Forest Service, has been put in charge of the whole work of assembling statistics, documents, and information for the Forest Products Branch. He further edits the general reports, is entrusted with special investigations, and ensures co-operation with the other economic organizations of the United Nations.

The work of the branches and sections as outlined above should not convey the impression that the Division's emphasis is on desk work. It has already become apparent that direct contacts with qualified representatives of the forest services of each country, investigations on the spot, and documentation gathered locally give quicker results than long hours of sedentary work. Each member of the Division's staff must be able to play the part of an ambassador for the world's forest economy in all countries to which his work may take him. This role obviously devolves in the first place on the Director of the Division who represents the Division at FAO's annual conferences, at meetings of the United Nations, and at the regional or world conferences organized by the Division or in which it participates. But the role also devolves upon the two chiefs of branches as well as upon the chiefs of sections and all members of the staff.

But the sending of one or the other of the Division officers to different countries cannot be sufficient to maintain the close contact necessary to the carrying out of its complex and long-term programs of work.

National FAO Committees are being set up in member countries to maintain liaison between FAO and the national administration, and the Director of the Division of Forestry and Forest Products has advocated that a forestry subcommittee should be created within the framework of each national committee. The Division would then be in a position to correspond directly with the secretary of the subcommittee avoiding, in cases where no policy issue is involved, the lengthy delays attendant upon official communications. The members of these subcommittees as well as their secretaries would always be representatives of their own countries, never of FAO or of its Division.

It is further considered necessary to organize regional forestry offices attached to FAO's other regional offices. Their officers will be placed immediately under the Director of the Division of Forestry and Forest Products and will supply the main office with information concerning their regions and carry out the Division's general policy in those regions.

For the time being, provision has been made for regional forestry offices in Europe, in South America, and in the Far East. The organization of the three offices duplicates the structure of the main office. Each is headed by a Chief of Branch, assisted by two officers, one for the forestry section and the other for the forest products section. The problems dealt with and the work of the officers are the same as in the main office, but on a regional scale, particular attention being paid to their specific problems. Thus, in Latin America, the main task of the regional office will be to take stock of the forestry resources of each country, of their development and systematic management, of the organization of the forest services, and of the development of administrative facilities. The Far East office will concentrate on reforestation and the co-ordination of forestry programs with the modernization of agriculture.

So far work has been commenced only by the European forestry office. It is headed by Mr. RENE G. FONTAINE, former Inspector of Waters and Forests of France, who is further entrusted with winding up the affairs of the Centre International de Sylviculture (CIS) and the Comité International du Bois (CIB) so that FAO can take over the documentation and libraries of these organizations.

Training the officers of the regional offices is a very important problem. It would be unwise to place them in posi-

tions outside the general framework of the central organization without affording them an opportunity to familiarize themselves with the methods and over-all policy of the Division. It has therefore been arranged to reserve in the subsections of each section of the main office at least one temporary appointment for an officer who, while carrying out his own work, will be in a position to gain insight into his section's work as part of the whole; this would be a preparatory stage to his employment in one of the regional offices.

This, in outline, is the structure of FAO's Division of Forestry and Forest Products. It will be noted that many appointments are still to be made and that until the majority of vacancies have been filled, the Division will have great difficulty in fulfilling even tasks of particular urgency. Nevertheless, the staff requirements are being gradually completed and without waiting for its organization to be perfect the Division can already point to achievements brought about by the teamwork and enterprise of its staff. Its contribution to the first two annual conferences of FAO has been noteworthy and the reports it has submitted have attracted the attention of specialists everywhere. Aided by two regional conferences, it has worked out questionnaires that will supply the scaffolding for much of its work. Lastly, the International Timber Conference of Marianske Lazne marked the first stages of practical co-operation among the European nations in adusting their forest policy to a common purpose and has implemented measures to remedy and perhaps entirely eliminate the timber shortage crippling postwar recovery in European countries, particularly in those ravaged by war.

It is to be hoped that these first steps are but the forerunners of more substantial achievements. The plans of the Division are in the custody of FAO's technicians, who, working as a team, will strive to bring them to fruition.

Conferences on Forest Statistics

Held in Washington 11-14 February 1947, and in Rome 31 March—3 April 1947

IN accordance with the recommendations of the Second Annual Conference of FAO at Copenhagen in September 1946, the Forestry and Forest Products Division undertook the preparation of two statistical programs. The first is concerned with an assessment of the forest resources of the world, their actual and potential productive capacities, the rates at which they are being used and wasted, and special losses arising from war. The second program provides for the preparation of periodic statements respecting production, stocks, consumption of forest products, and international trade in these commodities.

Draft questionnaires for use in both programs were designed by the staff of the Forestry and Forest Products Division and discussed in detail with the Economics and Statistics Division of FAO. Because of the great diversity between units in common use for the measurement of forest products, and because the statistical programs will be world-wide in scope, it was necessary to prepare lists of converting factors.

The importance of these statistical programs, and the considerable amount of work which will inevitably devolve on participating governments, made it essential to obtain the advice and approval of as many governments as possible before the programs were instituted. Arrangements were accordingly made for the calling of two statistical conferences, one in North America and the other in Europe. Through this means it was hoped to obtain the participation of the largest possible number of governments and to reduce the costs of travel as much as possible.

The Director-General of FAO invited governments of North and South America and the Far East to participate in a conference which was held in Washington from 11 to 14 February 1947. Subsequently, he invited the governments of all European countries and member nations in Africa and the Near and Middle East to take part in a conference in Rome from 31 March to 3 April. Fourteen governments sent delegations to Washington and thirteen nations were represented at Rome. In addition, representatives of interested international organizations participated in the work of these conferences, including the Caribbean Commission, the Emergency Economic Committee for Europe, and the Allied Control Council for Austria.

The Rome Conference reviewed the recommendations adopted in Washington, and it was found that very little difference of opinion existed. Since some minor differences between the recommendations of the two conferences were inevitable, it was agreed that the task of harmonizing these differences and preparing the questionnaires in their final form should be entrusted to the staff of FAO.

Both statistical conferences endorsed the proposals of the Division for a new inventory of the world's forest resources and for the institution of a world-wide program of annual forest products statistics. It was decided that, for the present, the collection of quarterly statistics on forest products would be restricted to the countries of Europe and the principal exporting countries of North and South America.

In general, the questionnaires presented for the consideration of the conferences were approved; many valuable recommendations, however, were made which will result in marked improvements in the series. Particularly valuable advice was received in connection with the complex and difficult matter of establishing a satisfactory series of converting factors.

The questionnaires have now been revised in detail and supplies are being printed in English, French, and Spanish. Distribution will begin at an early date.

As a result of the conferences, the Division feels that it has received the advice and assistance of the largest possible number of government representatives and experts, and that it can proceed confidently in the knowledge that its programs meet with approval.

International Timber Conference

At Marianske Lazne 28 April—10 May 1947

THE Second Annual Conference of FAO, held at Copenhagen in September 1946, recommended that an international conference should examine the urgent problem of lumber supplies in Europe. Lumber was essential for the reconstruction of countries devastated by the war, and there were clear indications that the timber shortage might produce a major social, economic, and political crisis.

Accordingly, in January of this year the Director-General of FAO joined with the Government of Czechoslovakia in inviting to an International Timber Conference all countries of Europe and the Near East and certain interested nations of North and South America, together with appropriate international organizations. The Czechoslovak Government offered a suitable location for the Conference at Marianske Lazne and formed a committee to make all preliminary arrangements.

The Economic and Social Council of the United Nations urged governments to participate in the Conference. As a result 135 delegates from 27 nations and 5 international organizations assembled at Marianske Lazne, 28 April.

All countries of Europe were represented, with the exception of the U. S. S. R., and it was possible to gauge the importance attached to the Conference by the quality and strength of the delegations sent by the various countries.

The Division of Forestry and Forest

Products of FAO had assembled for the Conference a quantity of material and statistics and had drawn on much of the valuable work of the Timber Sub-Committee of the Emergency Economic Committee for Europe. The agenda confronting the Conference appeared formidable, covering short-term problems, long-term problems, and further procedure. For working purposes, the Conference formed itself into three committees, each of which dealt with one of the topics on the agenda.

The Conference did not attempt to seek solutions for all the problems of forestry and forest products of Europe. Instead, it confined its attention to more limited objectives and, even in respect to these, regarded its recommendations only as a starting point.

The results achieved, however, were convincing and may be summarized as follows:

1. The Conference established for the first time a clear-cut picture of the size and nature of the timber deficit in Europe.

2. It brought about far-reaching agreements on a series of measures whereby it should be possible to bridge the gap between requirements and supplies in 1948 and 1949.

3. It definitely established the basic concept that in Europe problems of forestry and lumber cannot be dealt with nationally but must be considered in broad perspective, in the same way as FAO looks at them.

4. It demonstrated to the countries of Europe that FAO is ready to pass from generalities to specific tasks, and it brought forth a new reaction — that Europe wants and expects FAO to take an active part not only in forestry programs but also in plans for the distribution of lumber and forest products.

The next issue of UNASYLVA will be devoted to consideration of the Conference in detail, and further discussion is therefore reserved until that time.

The Conference closed on 10 May 1947 and the production of its final report reflected the exertions put forward by the Conference in the time at its disposal. It may be said that the results achieved were worth while, and not a little of the credit for the success is due to the unstinted efforts of the Czechoslovak Government and its representatives.

News of the World

Forestry

Forest Resources and Utilization

One of the most important tasks emerging from World War II is to take stock of world resources. Information is not easy to obtain so it was thought of interest to offer all figures that become available through news items in the press, yearbooks, reports, statements, etc., even if they often do not represent "news" in the accepted sense.

Canada

According to statistics quoted by the Maritime Lumber Bureau, Canada's total forest assets are 311,000 million cubic feet (8,800 million m^3) of standing timber. Of this total 191,000 million cubic feet (5,400 million m^3) are accessible under present conditions of operation. Forests in Canada are being depleted at the rate of about 3,000 million cubic feet annually, of which about 80 percent is used in forest-products industries, the remaining 20 percent being lost through fire, insects, and disease. The total forest area is estimated to contain 250,000 million board feet (1,100 million m^3) of accessible saw timber, spruce, *Picea*, and balsam, *Abies*, comprising the largest share of the total.

The Dominion Forest Service of British Columbia has developed a simple graphic method which permits rapid calculation of what spacing of tree per acre will produce the greatest increment per acre. According to this method, the average basal increment per tree is plotted over the number of trees per acre corresponding to the average spacing of the group, and a regression line drawn through the points. A second curve showing corresponding increments per acre is prepared from the first curve by multiplying the number of trees per acre represented by each ordinate by the increment per individual tree occurring at that ordinate and then plotting the value so obtained. For most data the result is a bell-shaped curve whose crest represents the number of trees per acre at which the stand should be carried to obtain maximum increment for the period under study. On the basis of a study carried out at the Petawawa Forest Experiment Station for a period of from 15 to 20 years after planting, it could be established that the maximum basal increment per acre for the period will be obtained if the plantations contain 600 trees per acre.

With the object of making a silvicultural and ecological evaluation of the factors affecting natural reproduction on logged and burned lands, the British Columbia Industrial and Scientific Research Council initiated in 1945 a project on a logged and burned area within the University Research Forest. An investigation of the degree of natural restocking in the burned area was also carried out, and plots were selected with a view to a comparison of the original stand and of the reproduction. Twelve quarter-acre plots were selected to represent (a) original forest types, (b) second growth forests, and (c) logged and burned areas of reproduction representing various combinations of soil and topographic conditions at varying distances from seed sources. At each location climatic and soil records were obtained, the seedlings and stumps of Douglas fir, *Pseudotsuga taxifolia*, Britt., cedar, *Thuja plicata* Donn, and hemlock, *Tsuga heterophylla* (Raf.) Sarg., were plotted and graphed, and the ground cover was analyzed. Besides, three strip surveys provided data on restocking.

Rumania

The latest data for Rumania list the total forest area at 6,326,000 hectares. 1,595,000 hectares are state owned, 2,671,000 belong to corporations, and 2,060,000 to private owners. Yearly production therefore should be around 14 million cubic meters. The forest area represents about 25 percent of the country's total surface with a per caput distribution of 0.33 hectares.

Belgian Congo

The total surface of the Belgian Congo is 234 million hectares of which 120 million hectares or 51.4 percent are forests of the equatorial type, 108 million hectares or 46.1 percent are savannahs, whereas lakes, rivers and streams take up 6 million hectares or 2.5 percent. Agricultural land including pastures would account for 14 percent or 33 million hectares of the total.

Southern Rhodesia

Among the increases of known resources of softwoods can be listed the discovery of a yellow-wood forest of at least 1,000 acres in extent in Southern Rhodesia on the Portuguese border. Two kinds of true yellow-wood grow in this area. The yellow-woods, one of which is *Podocarpus milanjianus* and the other probably *Podocarpus latifolius*, are true softwoods and will furnish valuable commercial timber.

United States of America

For the purpose of the countrywide study carried out by the United States Soil Conservation Service all lands were tentatively classified into eight types. These eight land-use capability classes (subject to change) are as follows: Classes I, II, and III—suitable for continuous cultivation at different conditions; Class IV—primarily pasture or meadow land but eventually also used

as cropland; Classes V, VI, and VII—suitable only for permanent vegetation, such as grass or timber; Class VIII—only to be used in a permanent type of vegetation which will not be harvested. From the results of the survey it appears that out of the 417,561,000 acres in cropland (169.4 million hectares) 88,581,000 acres should be placed to some use other than constant cultivation, and that there are 113,509,000 acres in grass and 32,934,000 acres in wood that are suitable for continuous cultivation.

On the other hand surveys show that about 25 million acres of private forest lands are idle and in need of tree planting. Millions more are only partially productive. Foresters are making great efforts to remedy the situation; here we bring an example of how they try to solve regional problems. According to calculations made by Burt P. Kirkland of the American Forestry Association, an increase of the annual cut in Douglas fir, *Pseudotsuga taxifolia* Britt., region of Washington and Oregon from 3,200 million to 13,100 million board feet (14.5 million m^3 to 59 million m^3) and possibly 20,000 million board feet (91 million m^3) is possible and practical. In his report he suggests how to increase the annual yield on a sustained basis and practice full utilization of forests through more intensive utilization, general thinning of young stands, and salvaging overripe trees or stands on federal and other virgin areas. Kirkland estimates that there should be a permanent core of 3,200 million board feet of production from the 320,000 million board feet in public and sustained yield private holdings, and 5,000 million board feet from other "free" private timber.

In the United States of America a prelogging experiment has been carried out wherein all pulp size hemlock 16 inches and under (40.6 cm.), down to a 4 inch top (10.2 cm.) is being removed in advance of regular logging. All gathered material is cut 40 feet long (12 m.) and is tied into bundles of approximately 8 cords (27 steres) with three wide steel straps. The average yield is about 8 cords to the acre. Lands already logged will be re-logged with the same equipment, thus raising the utilization factor to a point undreamed a decade ago.

That the subject of tropical woods is of interest not only to countries in the equatorial zone, is exemplified by a contract awarded by the United States Navy Department to the Yale University School of Forestry for the study of tropical woods and their suitability for shipbuilding, land structures and other types of naval construction.

According to present plans, a series of exhaustive tests will be carried out with a group of selected woods from Central and South America including analysis of strength properties, machining characteristics, decay resistance, and other significant properties. The object of the program is to attempt to find replacements for woods such as teak, oak, and other timbers now standard for various types of naval use.

The largest mahogany log ever to be manufactured into lumber was cut at a Bayou Chico (United States) mill. The log weighed 16 tons, measured 16 feet (4.9 m.) long and was 8 feet (2.4 m.) in diameter at the small end and 12 feet (3.7 m.) at the larger end. The log scaled 4,000 board feet (18 m^3) and would produce 88,000 square feet (8,200 m^2) of veneer. The giant log was imported from British Honduras.

Nearly 13 feet (4 m.) in diameter at the base, the largest Douglas fir, *Pseudotsuga taxifolia* Britt., tree known in forest service records has been cut in the Packwood forest, southwest of Mount Rainier in the United States. In spite of the fact that the 586-year-old tree was long overdue for cutting because rot had begun to eat at the base of the trunk and much of the upper part was decayed, the remaining section contained an estimated 11,076 cubic feet (313.5 m^3) of wood, or enough, theoretically, to produce 349,464 square feet (32,465 m^2) of plywood or 132,012 board feet of lumber (311.5 m^3), sufficient to build 58 five-room houses.

Germany

One of the grave problems facing European forestry and economy generally is the use to be made of Germany's forests. On the one hand are the war-ravaged countries which feel that Germany should be made to contribute to the ut most limit of her ability towards the reconstruction effort. On the other hand, there are many countries who view an excessive depletion of Germany's wood resources with grave anxiety as upsetting the whole economic structure and balance of Europe and as mortgaging the future with a problem it will take at least a hundred years to readjust. We are going to quote from various sources to show how the question is being handled. According to an article "Future of German Forest Resources," appearing in *Wood* for December 1946,

"The manner in which German forest resources are handled by the occupying powers in the immediate future may well affect the German economic structure for generations to come. At present the artificial barriers raised by zoning impose a disproportionately heavy burden on the forests within the British zone. These forests represent only 15 percent of the total German forest area while the British zone is the most densely populated of the four zones into which Germany is now divided. Of the remaining 85 percent of German forest lands, the Russian zone has 44 percent, the American 29 percent, and the French 12 percent. Some timber is being sent from the American and French zones to the British zone, but the total amount set against the domestic and industrial requirements of a community of 22 million people is negligible. And so, to keep pace with essential requirements, the forests in the British zone must be sacrificed. The alternative of this unbalanced position is the administration of German forest resources as a whole irrespective of zoning. Only in this way will a fair distribution of wood be ensured while the essential structure of forests would stand a good chance of survival."

According to *Timber News* for February 1947,

"The plans for the 'Harz project' were carried out after a comprehensive survey of the area involved in July 1946 by the North Germany Timber Control and consist in the clear-felling of about 13,000 acres (5,300 hectares) containing over 3 million tons of millable spruce over 80 years old. Both round logs and sawn timber are being provided under the scheme." *The British Zone Review* maintains that one undeniable fact concerning forest management has emerged from the work done already, and that is, the German rotation system of 120 years is 20 years too long The operation has already demonstrated that invariably much good timber is spoilt by butt rot after 100 years of growth, and the Germans have been quick to learn the lesson and have now adopted a rotation of 100 years.

An article on overcutting of wood appearing in *Holz*, No. 17, Vol. 60, 1947, states that according to releases from the news agencies in the Amerizan zone of Germany, twice as much wood has been cut as normally allowed, and in Wurttemberg Baden even four times as much. In this last region the amount cut was 3.7 million *festmeter*, of which 1.5 million was used as firewood. The amount of firewood consumed had the calorific power of 200,000 tons of coal only.

Argentina

Argentina has adopted a five-year plan for the exploitation of the forests of the Rio Negro and Chubut Territories. A special commission sent to investigate has estimated the exploitable area at 30,000 hectares from which 40,000 cubic meters of wood could be taken. Three technical commissions are now going to make detailed surveys and determine methods of rational utilization.

U. S. S. R.

In order to satisfy special needs, particular species have received marked attention. Thus the U.S.S.R. is carrying out a plan to obviate the necessity of importing some 20,000 tons of cork as was the case before the war. The plan provides for a yearly planting of 2,500 hectares in order to achieve a total area of 75,000 hectares. Before the war some 20 to 25 tons of acorns were imported from Tunisia, Algeria, Portugal, Spain, and Morocco to supplement the home-grown production of 3 tons a year. The acorns were usually shipped to Batum on the Black Sea They were then planted in pots in the autumn and kept in greenhouses. As soon as the seedlings reached a height of 10 centimeters, they were transplanted in lines of 6 meters by 8 meters, which meant 250 trees per hectare.

Forest Policy

United Kingdom

It has taken the experience of two wars to show that long-term policies are necessary to ensure adequate supplies of both food and timber in the United Kingdom. In 1939 a mere 4 percent of British requirements of timber were produced and the commencement of a large exploitation of its woodlands found a considerable part of them still suffering from the heavy cutting carried out during the First World War.

During the recently concluded war timber imports have been severely reduced and home timber production stepped up. The following official figures illustrate the position: Home timber production was 450,000 tons in 1935-38 and 3,821,000 tons in 1943; whereas timber imports were 9,662,000 tons in 1935-38 and 1,708,000 tons in 1943.

As a result, little mature timber remains and England has been forced to draw upon supplies of immature timber. In view of this position and the growing world timber shortage, extensive replanting and expansion of forests are imperative. As of 30 September 1939, the National Forest Estate amounted to 1,144,000 acres (463,000 ha.), including Crown woodlands. Therefore, of the 5 million acres (2 million ha.) of effective forest, which the Forestry Commission proposes securing over 50 years, 3 million acres (1,200,000 ha.) are to be obtained by afforestation of bare ground (mostly rough grazing) at "relatively small" loss to food production.

The remaining 2 million acres (800,000 ha.) of the proposed Forestry Commission program are to be secured by selection from existing woodlands. They will either be "dedicated" to forestry and worked to an approved plan of operations, when their owners will become eligible for State assistance, or acquired by the State.

Australia

The New South Wales Government has decided to spend in 1947 double last year's amount on forestry development. Three hundred and ten miles (500 km.) of new roads will give access to new areas. Emergency logging of the Upper Hastings will be speeded up and during the year 16,490 acres (6,670 ha.) of hardwoods and 8,960 acres (3,630 ha.) of cypress pine, *Callitris spp.*, will be reafforested. A start will also be made on planting hoop pine, *Araucaria cunninghamii* Ait., on 327 acres (132 ha.) in the Tweed-Richmond area, and certain areas of private timber land will be acquired.

Kenya

The planting scheme for Kenya, initiated in 1922 by the Founder of the "Men of the Trees," is carried out by the Forestry Department of Kenya which carefully replaces timber cut from forests by replanting them with suitable young trees. Its activity is particularly important and essential as in Kenya timber is not only used for building purposes but also as a substitute for coal for the railways.

United States of America

A broad program for the development of forest lands in the United States to meet continuing high-level requirements for wood and wood products has been proposed by the American Forestry Association after a nationwide survey of the effects of war drains on the country's timberlands and their capacity to meet postwar needs.

The program calls for greater emphasis on State and private responsibility in the handling of forest-producing lands, including state action to curb destructive timber cutting; a record-breaking tree-planting project of 20 million acres (8 million ha.) during the next 12 years; greatly intensified action to bring all forest land under protection from fire; and a vigorous nationwide expansion of forestry education, including advice and assistance to the 4 million owners of small forest properties who control 57 percent of the commercial forest land of the United States. Specifically, the program covers the following items: protection of the forest resources from fire, protection of forests from insects and diseases, education of the American public, education and assistance for forest owners, control of destructive practices, forest planting, forest taxation, forest and wood-use research, forest credit and insurance, intensive timber production, co-operative sustained-yield units, Federal, State, and private forest ownership, current forest inventories, and recreational and aesthetic values.

Norway

The Norwegian Parliament has unanimously voted an allocation of 3.15 million kroner (approximately U. S. $635,000) for private forestry during the fiscal year 1946/47.

Silviculture and Reforestation

United States of America

A movement called "tree farms" began in the Pacific northwest of the United States in Gray's Harbor, Washington, five years ago. It was then that a tract of forest land was set aside and given the name of the Clemons tree farm. It marked the beginning of a new era in forest management, although many forest owners were consciously "growing trees for tomorrow" long before the program known as "tree farms" actually started. The term "tree farm" caught interest and added incentive to forest owners, large and small. In the five years which have followed the official adoption of the title, it has become a significant factor in the United States' forest future. Nowadays the national total of forest acreage certified is 12,922,231 acres (5,229,459 ha.) in the 15 states which have adopted the program. Encompassed in these states are 1,053 testified farms. The tree farms can range from 5 acres (2 ha.) up to any amount. As a matter of fact, the smallest tree farm is just 5 acres while the largest is 700,000 (283,000 ha.) and they are both located in the largest state in the Union—Texas.

Realizing that the production of nursery stock will have to be increased to meet future demands and needs, state foresters are making plans to grow from three to ten times as many trees as were produced in 1946. Georgia, with 2 million acres (800,000 ha.) in need of planting, plans to grow 30 million seedlings for distribution in 1947 at the two state operated nurseries at Flowery Branch and Albany—with 70 percent coming from the latter nursery. Another southeastern state, South Carolina, has purchased additional land and is now making tentative plans to grow 15 million trees for 1947 compared with 2,175,350 trees for 1946.

During a five-year period from 1947 to 1952 Oregon will levy a tax of 5 cents per thousand feet of logs (4.53 m^3) produced, to be dedicated to research in forest rehabilitation and direct scientific investigation by the Oregon Forest Products Laboratories. Forty percent of the money to be collected on an estimated annual cut of 5,000 million board feet (23 million m^3) a year will go to forest rehabilitation studies — U. S. $100,000.

Canada

The British Columbia Research Council, in collaboration with the University of British Columbia, began a survey in 1945 of the effects of various factors, such as rainfall, light and shade, and location of seed trees, on the extent to which re-seeding occurs in logged areas, on the types of trees which form the second growth forests, and on the rates of growth. In close conjunction with this work, methods are being developed for accurately and efficiently surveying large areas to determine the extent and nature of reforestation.

A "tree planting car" of the Canadian Forestry Association was visited in the past 25 years by more than a million people; it travelled 2,906 miles (4,676 km.) on the Canadian Pacific and Canadian National Railways and held 338 meetings attended by 40,776 persons. In its staff's spare time 194 farm homes were visited to assist in tree planting problems and more than 300 letters of inquiry from farmers were answered with complete information. The purpose of the car's activity in the open prairie is to teach the fermers how to plant shelterbelts, which is the first step in creating profitable food gardens, in the protection of livestock, and the ameliorating of living conditions.

France

A National Forestry Fund is to finance reforestation in France by a levy of 9 percent on the value of forest products. Some 2 million hectares are to be reforested of which one million hectares are old forest areas depleted by fire or abuses. The reforestation program is to be completed in 10 years.

New Zealand

Rimu *Dacrydium cupressinum* is the most important tree species milled in New Zealand. For instance, out of a total output of approximately 341 million super feet (805,000 m^3) of timber in 1942-43, 198 million (467,000 m^3) was made up of that species. Rimu stands are found throughout New Zealand, but, having a very slow growth rate, they are in danger of being heavily depleted, the trees at present being milled varying in age from 250 to 600 years. Foresters therefore believe that, even under management, it would take at least 200 years before a second crop could be obtained. Unfortunately, rimu is an infrequent and sparse seeder and, except on the West Coast, does not regenerate freely. More

over, it has been found impossible to handle it in seedling states whether it has been raised artificially in nurseries or has been naturally regenerated. What is true for rimu, is true also with minor modifications for totara, *Podocarpus totara* D. Don., matai, *Podocarpus spicatus* R. Br., and white pine, *Podocarpus dacrydioides*. The Forest Service has realized this for many years and accordingly has established large areas of fast-growing introduced species.

Experimental work using a helicopter to reseed logged-over land is being undertaken. A newly developed tree seed pellet coated with fertilizer, root hormone, and a substance toxic to rodents will be used in the experiment. This seed pellet, it is said, makes tree seeding by aircraft possible for the first time.

Forest Fires

France

The southwestern coastal regions of France suffer most from forest fires that have wrought great havoc in the pine forests from 1940 to 1946. A decree of 25 March 1947 creates a fire fighting corps for the three departments which have suffered most. It is not a group of volunteers but rather a professional body of specialists in forest fire fighting the members of which, even though they may be employed for other forestry work, will always be on call to be sent wherever a fire is detected. The corps will be financed by the National Forestry Fund established by the law of 30 September 1946.

Canada

Forest fire losses in British Columbia during 1946, amounting to Canadian $357,984, was only about 25 percent of the previous year's figure. Accessible merchantable timber killed is placed at 63,992,000 board feet (290,000 m^3) of which 16,150,000 board feet (73,200 m^3) is salvageable. One hundred and fifteen, or 30 percent of last year's fires, were started by lightning, with damage estimated at Canadian $43,827. Smokers were blamed for 326 fires, and brush burning caused 117; industrial operations, including logging, were the source of 38, and campers were responsible for setting 263. Ten fires were tracked by the Forest Service to incendiary causes.

Australia

The Forest Commission of Victoria, Australia, has recently carried out a test of the bombing out of bush fires at Anglesea under realistic conditions. Mustang planes dropped 750 pound bombs on patches of fiercely blazing scrub. The results are regarded as most encouraging by the Commission and further testing will be carried out in due course.

United States of America

Water bombs will be used to check forest fires in the north-western forest regions of the United States. One type will hold 160 gallons (606 liters) and the other over 300 gallons (1,136 liters). They may be fused to burst forty or fifty feet (12 to 15 m.) above ground or on impact. Bomb-dropping B-17 airplanes will be used.

Forest Enemies and Pests

Australia

A number of native Australian woods are susceptible to "dark heart" which considerably affects their utilization value. The Division of Wood Technology is trying to obtain a better appraisement of the extent and peculiarities of this condition. If its cause can be determined, it will be possible to provide better protection to many of the young susceptible softwoods now being planted.

New Zealand

According to Mr. G. B. Rawling, an entomologist of the State Forest Service, New Zealand forests are in a particularly healthy condition. He carried out an inspection to investigate the possibility of the introduction of new tree diseases during the war years, but he did not discover any new species nor did he find that any of the destructive fungi and insects already known had caused significant damage.

United States of America

In the United States the sugar pine cone beetle, *Conophtorus lambertianae*, is normally a destructive pest of immature cones. Nevertheless, recently a twig-mining habit which had previously escaped observation was discovered, which indicates that in certain years at least a part of each brood reared in the cones emerges in August and September, and then attacks the twigs. The effect of the twig killing is not looked upon as particularly damaging to the tree as a whole, because the amount of foliage destroyed is relatively small. However, it has a scientific interest as it brings out a new phase of the seasonal activity of a well-known forest insect.

According to Dr. Ray R. Hirt, forest pathologist of the New York State College of Forestry, scientists have not succeeded in controlling the Asiatic chestnut blight nor yet discovered an immune American chestnut. Dr. Hirt is now studying chestnut hybrids not only for their resistance to the plague, but for growth characteristics. One of the most important aims is to discover forms that may be valuable as food for wildlife as well as for lumber and orchard purposes.

Tests recently made on a large western tree farm may point the way to increasing timber supplies by killing insects which kill trees. DDT sprayed on a forest from the air destroyed 4,300,000 tree-devouring insects per acre.

A new tree paint that will help heal tree wounds in two-thirds the time normally required has been put on the market. The tree paint contains plasticized asphalts, resin, lanolin, and fungicides, including pinenem bornyl acetate, and sylvestrenes. The tree paint prevents the drying out and death of the living outer cells.

United Kingdom

It has been estimated that, reckoned in food crops and young growth destroyed by the rabbit in the United Kingdom, each rabbit costs the country at least one pound sterling. Total loss after deducting the price obtained for the rabbits sold is estimated at 140 million pounds sterling

Forest Products

Technology

United Kingdom

The British Timber Development Association has set up a Constructional Research Directorate. The definition of its functions and scope is interesting as a practical program of bringing scientific activity to bear directly on industrial activities. It is summarized as follows:

1. Research— a) Industrial: General survey of industrial problems in the timber-consuming industry; b) Scientific: The initiation and direction of research in national, university, industrial, and private laboratories; the collation and interpretation of results obtained in the United Kingdom and abroad.

2. Development—Experimental application of the data obtained through 1. a) and b) above; collaboration with, or employment of research laboratories or industrial organizations in the use of new materials, methods of construction production and technique; experimental construction.

3. Design—The elaboration of analytical design methods appropriate to timber; the compilation and tabulation of design data.

4. Educational—Publication of the results of 1, 2, and 3.

5. Standards—Services to the committees of the British Standards Institution, Codes of Practice, professional distributions, building and engineering councils, etc.

6. Advisory services — General assistance on all matters of timber utilization.

Australia

The Australian Council for Scientific and Industrial Research at its Forest Products Laboratory in Melbourne is continuing its investigations on wood chemistry and wood fiber structure in its efforts further to develop the utilization

of Australian woods, chiefly eucalypts, in the woodpulp, paper, cellulose, and other wood chemical industries. The establishment of a paper industry using short-fibered eucalypt woods as the source of pulp made by mechanical, soda, and kraft processes became possible only as the result of the perseverance of Australian scientists who, despite pessimistic opinions of European and American technicians concerning its possibility, persisted with the will to be successful. The Australian paper industry, now employing about 20,000, is planning expansions of plant and products to reduce the volume of imports now necessary from overseas.

Other fields being investigated by the Australian Forest Products Laboratory include:

1. The preservation, by high pressure impregnation with water soluble preservatives, of nondurable eucalypt woods which cannot be treated satisfactorily by regular creosoting methods. This work is being carried out as supplies of durable hardwoods previously used for sleepers are insufficient to meet requirements for maintenance of existing tracks and new constructions which will be necessary under plans for the unification of railway gauges throughout Australia.

2. The investigation of the possibilities of using hardwood logs, chiefly *Eucalyptus spp.*, for the production of rotary veneers for plywoods. As a result of research carried out, a commercial plywood plant using karri, *Eucalyptus diversicolor* F. Muell., has already been established in Western Australia. It is anticipated that commercial operations on jarrah, *Eucalyptus marginata* Sm., will soon be commenced.

Canada

The Canadian Research Council has completed the reconversion of its activities from war to peace. War research facilities that had attained great proportions had to be discontinued or modified to meet the growing industrial requirements of peace. A Building Research Division has been established to ensure a complete coverage of Canada's housing needs. A National Building Code has been published to serve as a model in the drafting of municipal bylaws. A model zoning law has likewise been prepared. The development of a modular system for the construction of prefabricated houses has brought an important advance in lowering the cost of this type of housing.

A school for sawing, classification, and mensuration techniques has been opened at Duchesnay in Canada. The school is to serve as a center for research work in utilization, woodworking and by-products, and to train specialists in all branches of the sawmill industry. Schooling is completed in the following courses: A. Construction, maintenance and operation of sawmills (two periods of nine months each); B. Cutting and sawing of logs (nine months); C. Sawing and trimming for grade of sawn logs; D. Mensuration and grading of logs and lumber (nine months); E. Artificial and open-air drying of lumber (four and a half months); F. Manufacture of by-produts (four and a half months); G. Saw-sharpening (four and a half months); H. Log scaling (four and a half months).

United States of America

A very interesting trend becoming apparent not only in the United States is illustrated by the plan of the old Maryland Institute of Fine and Practical Arts to organize courses leading to careers as modern cabinet or furniture designers. Particular stress is laid on the use of modern materials.

The manufacture of yeast from wood is not new. The Forest Products Laboratory at Madison, Wisconsin, however, is investigating a most important aspect of this scientific technique, that is, of overcoming its economic hazards. The aim is to develop a simple process to allow for local manufacture utilizing wood of poor quality in order to bring a high protein yeast suitable for poultry and livestock feed within the reach of the small farmer to help him solve his feed problem.

A nailless wooden box has been developed by the Wooden Box Institute in the United States of America. Glue and tape are used instead of nails, and lumber is saved by reduction in thickness of panels. Tests have shown the box to be at least as strong as the usual nailed type notwithstanding the fact that one third less wood is used.

A Building Construction Research Board has been set up in the United States of America to serve as a clearing-house of technical research information in that field. Its principal function will be to collect and disseminate technical research information of importance to the building industry. It will also provide a meeting place at which those actively engaged in research activities will be able to exchange ideas, and a mechanism for the correlation of activities carried on simultaneously by several organizations. No direct laboratory activity is contemplated.

A new laboratory to work on treatment of Douglas fir, *Pseudotsuga taxifolia* Britt., and other western species was established at the Wauna, Oregon, plant of the American Lumber and Treating Company. Research work will include pressure treatment of full-length lumber, resin impregnation, gluing of pressure-treated wood into large structural members, and strength testing.

Sweden

Sweden is schooling its sawmill personnel in special schools which teach not only working techniques but also safety rules and practices and labor and union regulations and legislation. Special studies of psychological and dietary aspects of woodworking operations are carried out.

Industrial Equipment

United States of America

A type of bandsaw differing from the usual has been brought out in the United States of America. The corners of the teeth alternate right and left. This is said to have the following advantages: a) the saw is balanced; b) it has a better cutting edge; c) there is no twisting; d) sharpening and setting time is saved; e) power and labor are saved. A new type of jig-saw blade has been put on the market. The blade is circular in section and cuts in any direction. The teeth form a regular spiral. It is claimed it will cut all woods, light metals, and plastics.

A portable saw-sharpener for filing hard tooth saws without necessity of removing the saw has been introduced. Its principal feature is the clamping device which enables fastening securely of the drill type motor and grinder to the saw and at the same time allowing for quick adjustment for proper filing angle. Weighing approximately 8 pounds (4 kg.), the sharpener is quickly mounted on the saw.

A new tool is used in reclamation of old lumber in razing jobs and has proved an amazing success in split-free removal of sheathing, siding, flooring, and other lumber, which remains usable for other installations. The tool lifts flooring, siding, roofing, and other wood with such care that no cracks, splits or breaks occur to lower its value. It also lifts adjoining pieces of tongue-and groove flooring and shiplapped siding with equal ease and damage-free care. It is handled with great ease, and using it, it is possible to remove more lumber in one hour than is possible in three or four hours with old-style methods, so that it will also prove valuable in the saving of labor costs.

During the war the United States Army, one of the largest users of dunnage and crating lumber, designed and constructed a remarkable labor money saving machine. This machine makes the task of processing planks, boards, timbers, and lathing for re use as simple as the job of stacking this renovated wood. With just one such machine it is possible to process 2,000 board feet (4.7 m^3) an hour. It can extract 250 to 300 pounds (113-136 kg.) of nails in a day.

Compactness and one-man operation are the principal features of a new post machine which produces triangular corner posts from 1⅝-inch or 1 9/16 inch stock (3.49 cm.) in length up to 24 inches (61 cm.) and at a rate of 60 per minute. One of the outstanding new features of the machine is a safety cover enclosing all moving parts.

A working model of a pole-peeling machine has been completed. It is constructed to peel 2,000 feet (610 m.) of poles per hour or one 40-foot (12 m. pole) per minute and thus to obviate the lengthy and costly skinning of telephone poles by hand. Compressed air drives a series of rotary knives skinning the pole and achieving a smooth surface.

A pulpwood grapple has been designed to transfer small wood directly from delivery cars to the working floor. It permits economical recovery of small timber and so increases the production of pulp, saving, in some instances, 20 per cent in wood usage.

In the United States of America a live log deck has been designed to be built chiefly from used standard tractor parts. The "chain" will be powered through the tractor drive sprockets at one end and will run over tractor front rollers at the other end. A 5 h.p. motor provides the power. A log lift brings the logs to the deck from the pond. The new mill will have two 60-inch (1.52 m.) circular saws. It is expected to cut 45,000 board feet (106 m^3) per shift.

Canada

A Canadian sawyer has devised a plate glass guard for hand saws which represents a great advance over the usual ware screen. It affords a clear and uninterrupted view down the roll case and in particular of the tailsawyer. It protects him from flying objects. It is mounted so as to enable the operator to eliminate reflection or to turn it completely round for easy cleaning. A further safety device has been installed at plants in Canada. It is a remote control sawdust mover or agitator for fuel bins which eliminates the entering of a fuel bin for the purpose of raking down or loosening of banked sawdust.

Preservation and Drying

Canada

A new fluid preservative, developed in Canada during the war and widely used by the Allied field forces, is expected to cut appreciably the loss due to wood and fabric decay. This preservative has an effective penetration which prevents the entrance to the cellulose tissue of any fungus or insect, thus blocking access to the vulnerable areas upon which such parasites subsist. Its action is permanent, so that the life of the wood may be prolonged in some instances to five or six times the normal expectancy. It can be painted, sprayed, or applied by immersing the material in a bath of the fluid. The cost is low.

United States of America

A co-operative study covering the preservative treatment of certain West Coast timber species has been undertaken by the Oregon Forest Products Laboratory at Corvallis. The American Wood Preservers Association, which establishes official treating standards for the lumber industry, recently called upon the laboratory for assistance in obtaining technical information covering current treating schedules for western hemlock and intermountain type Douglas fir.

The Forest Products Laboratory of the United States Department of Agriculture announced that a nonswelling wood has been produced by the Department's chemists. According to the new method, wood is placed in a "steam bath," the steam being a vapor of pyradine, a coal tar derivative, and of an acid closely related to that in vinegar. This vapor permeates the cells of the wood, swelling it. But this swelling is permanent. There is no return to the wood's original dimensions.

In the United States of America, chemically treated fire-resistant wood is being developed by the National Bureau of Standards in Washington, D. C. The chemical mixture used includes ammonium salts, borax, and boric acid. The wood is impregnated with a solution of these, resulting in effective fire retardation of up to 33 percent.

Aware of the greatly accelerated process of decay in wood in tropical and semi tropical climates, an American automobile manufacturer delivering to Hawaii has solved this problem by constructing cab framings with pressure-treated wood, and by using phenolic resin glue which is decay and mildew proof. Laminated sections made up in that manner produce higher strength and greater freedom from splitting than individual solid sections.

The discovery of a method of drying lumber by boiling has been announced in the United States of America. The formula for the liquid in which the lumber is boiled has been covered by a patent. The logs are cast into the fluid at a temperature of 250° F. (121° C.). Since boards would burst at around 260° F. (127° C.), thermostats are used to control the temperature of the solution. It is claimed that the lumber so treated neither warps, curls, nor bursts during the process and that the solution can be used for an indefinite length of time.

Australia

A new timber drier has been designed by the Division of Forest Products of the *Australian* Council for Scientific and Industrial Research. This is a pre-drier for sorted timber, which operates on a progressive principle, and yet avoids the necessity for the usual periodic movement of the timber stacks within the drier. Incorporated in the design is a method for utilizing boiler exhaust flue gases as the heading medium. It is stated that the pre-drier is capable of taking multiple timber charges each 8 feet high (2.4 m.) by 35 feet long (11 m.). The specific purpose of the unit is to give economic pre-drying from the green condition to a moisture content of 25-30 percent for subsequent kiln drying.

Plywood and Gluing

Canada

An entirely new type of wall-covering composed of one-inch (2.5 cm.) jewel cut squares of plywood bonded to a fabric backing is now being sold in Canada. Research has shown it versatile enough to be applied to both flat and curved surfaces for wall decoration, molding, furniture, trim, etc., to particularly good effect. The unselected plywood faces furnish an excellent surface for painting. Produced in sheets 24 inches square (approx. 155 cm^2), the V-cut divisions between each square make joints invisible and allow for a perfect fit on inside and outside corners.

A new panel product is now being produced. It is plywood surfaced with a smooth, hard, durable face made from wood waste which has been pulverized and bound with resin. It is reported that present plans are to use only "clean waste," i.e., sawdust, sander dust, and other small wood waste particles which are a by-product of plywood manufacturing. Any thickness of plywood can be used as a base for the resin-bound surface, it is claimed. Using as a base exterior type plywood and using waterproof adhesives, the finished panel is said to be suitable for outdoor as well as indoor use.

United States of America

A new panel consisting of resin-impregnated sheet material, cured and assembled into the form of nested hexagonal cells and faced with sheets of aluminum or plywood, has been developed in the United States of America. Unusual strength and lightness are claimed for the new material.

A new type of laminated wood rollers now being produced in three weeks for wallpaper and linen manufacture in the United States of America may displace solid wood rollers that usually require four years to manufacture. The new rollers, made of thin, hard maple board, glued with waterproof adhesives, are said to eliminate seasoning defects and uncertainties of behavior in operation.

A new type of laminated flooring has been developed recently. It is claimed that the new material is the equal of top quality conventional hardwood flooring. The material is a three-ply cross laminated hardwood flooring 12 inches wide (30.5 cm.) and comes in any desired length. It is made in a continuous glue press from small-size cull type hardwood logs not ordinarily adapted to the production of hardwood flooring. Because of its width—12 inches as contrasted with the 2¾ inch (approx. 7 cm.) width of conventional flooring—the new type flooring can be laid with less labor and its cost is competitive.

A new use has been found for over-ripe and over-aged alder by making it a premium interior finishing wood, to which the stain, fungus growth, and over-age markings has given a particularly distinctive appearance. The manufacturer of the new material soon found that he had more takers than he could supply.

A new method of hardwood furniture manufacture that fully protects the original beauty, high polish, and natural sheen of home, office, and hotel furniture tops from water and alcohol stains, heat due to hot plates, coffee pots, and burns from cigarettes and cigars, has been developed recently.

For some years it has been widely known that a thin sheet of aluminum inserted between a furniture core and the face veneer would conduct the heat from a burning cigarette away from the face veneer rapidly enough so that no damage would result to the wood surface, provided the finish itself was heat resistant. But in the past some difficulties prevented the practical utilization of this fact. Now a new process has been developed which makes use of a new type

of gluing technique, whereby a thin sheet of specially prepared aluminum (as thin as 0.002 inch or 0.508 mm.) is attached to the core and face veneer by means of cold adhesives, making unnecessary the use of expensive hot presses. Because the aluminum is attached to the wood by cold bonding adhesives, there is no danger of expansion of the aluminum, and, therefore, warping through this cause is eliminated.

Progress in the application of radio frequency heating, with special emphasis upon wood products, was reviewed and its future possibilities explored at a conference in Seattle, United States of America, 16-17 January 1947 and sponsored by the College of Forestry of the University of Washington and the Division of Adult Education and Extension Services. The function of radio frequency heating and its application in the field of wood products were dealt with; it was also claimed that it effects lower unit costs in many applications, and gives better uniformity of heat; it is also capable of doing many jobs impossible with other forms of heat. It does remarkably well on small articles and is especially useful in producing curved laminates of various types, such as barn rafters, roof trusses, and spars. But the men needed to operate this type of heating must have more than usual technical training. The difficulties encountered by the radio frequency heating industry in getting satisfactory wave length assignments have been stressed. The properties and characteristics of glues suitable for RF applications were studied by a special panel which developed many interesting data on this topic.

A phenol-type adhesive has been developed, especially formulated for bonding wood with radio-frequency equipment. According to the makers, it eliminates one of the worst drawbacks in gluing with dielectric heat. It does not arc when electrodes come in contact with the squeeze-out of glue or with the glue line itself. At the same time it allows the use of maximum power to provide quicker curing. This makes the radio-frequency method practicable for many new wood bonding operations.

As walnut shell flour, more than 90 percent of the particles of which pass a 325 mesh screen, came into general use, advantages other than its reduced cost became apparent. They can be summarized as follows: a) the particles of walnut shell flour are dense, tough, nonabsorbent, and do not swell when wet with water; b) it is nonabrasive and does not dull cutting tools; c) mold and fungi will not germinate in synthetic resin adhesives containing walnut shell flour; d) it aids in mechanically spreading and distributing glue solutions smoothly and evenly; e) its fine particles fill and seal the pores of wood.

United Kingdom

The possibility of gluing metals to metals and metals to wood is of great interest to engineering designers, and has already been exploited in aircraft designing. It is a structural advance of some significance. A new British process provides a bonding method for joining metals to metals, metals to wood, and metals to plastics. The joint is thoroughly resistant to water and solvents, does not deteriorate with age and maintains full strength in the temperature range from 40° C. to 60° C. The labor involved is practically unskilled and the application process is extremely varied.

Pulp and Paper Industries

Canada

A chemical process for loosening the bark of pulpwood trees while they still stand in the forest was announced at the Canadian Pulp and Paper Association's annual convention in Montreal, 30 January 1947. Tested and found successful by the government investigators, some of the chemicals used in the process have yet to be tried on a large scale by the pulp and paper companies themselves.

The new method would permit the hand barking of pulpwood to be continued through the late summer and fall months, instead of ending around the last of July as at present.

The chemical soluble arsenic, ammonium sulphamate, sulphamic acid, and sodium chlorate, have proven the most effective of those used in the experiments. They are applied to the trees in the form of a paste during the "sap peeling" season, in spring and early summer. Of all the chemicals tested, arsenic proved to be the speediest and most effective in removing bark and providing protection from blue-stain and bark insects which frequently attack dead trees. Pulpwood trees tested were white spruce, black spruce, balsam fir, jack pine and paper birch. Cedar trees for telephone poles were also treated. The trees killed by chemicals in the woods dry out to a certain extent before they are felled, the amount of drying depending on the interval between treatment and felling.

United States of America

It is claimed in the United States of America that lignin salvaged from wood pulp at paper mills can be used to give Buna-S, a synthetic rubber substitute, greater value. Buna-S can be manufactured for a price which compares favorably with the average price of natural rubber. Substituting lignin for carbon black as a reinforcement for Buna-S has apparently made it possible to produce the reinforced Buna-S in a relatively wide color range.

A new paper, possessing unusual qualities that made war maps durable in the water, mud, and grime of the battlefield, was developed early in the war by U. S. Army Engineers in co-operation with the National Bureau of Standards. High wet-strength, obtained by the relatively new development of resin bonding, constitutes the most important feature of this paper, which is resistant to conditions that disintegrate conventional papers. Though developed primarily for war maps, it offers numerous peacetime uses—such as for bed sheets, bath mats, washable towels, wrappings for wet meats and vegetables, and outdoor advertising.

The Bureau of Standards carried out experiments to determine how such paper could be made from available raw materials. Rag fibers were not considered, so that the experiments were confined to commercially available bleached wood pulps: three types of bleached sulphates, bleached sulphite, deciduous wood soda, and deciduous wood sulphite. The manufacturing process for the high wet-strength paper follows the same steps used in making conventional paper, the only differences being a shorter beating cycle and the addition of resin bonding.

Professor R. G. Tyler of the University of Washington Sanitary Engineering Laboratory has disclosed a method of combating pollution of rivers and waterways, suggesting the use of equipment developed at the University which will restore the oxygen content of the polluted waters by pumping compressed air through porous diffusers. The process was tested on the Flambeau River in Wisconsin and found successful, and has been found to be useful in tidewaters as well. The mills have been accused in recent years by conservation and sportsmen groups of killing fish life with the noxious waste liquors from pulp processes.

Building Construction

France

A new type of flooring developed in France and first shown at the Paris Wood Exhibition in September 1946, is made up of short lengths 11 centimeters long, 2.24 centimeters wide and 1 centimeter thick. These pieces have a lengthwise ridge 2 millimeters thick. They are glued on a cement layer by a special adhesive that remains flexible. A special manufacturing process allows for a much better utilization of the wood employed and elimination of all faults. It also makes possible a saving in transportation: whereas a freight car of 10 tons can only load about 600 square meters of normal parquet it can take 1600 square meters of this new type. The usual type of parquet is 8 centimeters high with joists whereas this type will not be more than 1.5 centimeters. That means a gain of 6.5 centimeters per floor.

Canada

For a large repair shop in Canada a floor had to be constructed having a life load of 500 pounds (2,400 kg/m^2) per square foot to be carried on joists spaced at 5 feet (1.5 m.) center and spanning 25 feet (7.6 m.) on concrete piers and footings. For such a load and span, solid timber beams would have to be of a size that was quite out of question, while substitution of steel beams or concrete floor slabs would have greatly increased the cost of the structure. The problem was solved by the use of trussed joists assembled with split ring timber connectors. These trusses, of select common Douglas fir, 8&S, consist of two members in chords, the top members being comprised of two pieces of 4 x 16 inches (10.2 cm. x 40.6 cm.), and the lower members two pieces of 4 x 12 inches (10.2 cm. x 30.5 cm.). The 3-inch (7.6 cm.) diagonals are doubled for compres-

sion members. Connections between top chords of trusses were made with malleable iron hubless shear plates. The laminated deck consisting of 2 x 6 inches (5.1 cm. x 15.2 cm.) fir planking on edge, was treated throughout with wood preservative. When completed, a 25-ton tractor was moved over the floor without producing any deflation whatsoever.

A new type of scaffold assembly has been designed in Canada which utilizes metal corner brackets and metal clevises on uprights to support staging. Savings of 75 percent in erection and disassembly time, 90 percent in nails and transportation, and total recovery of lumber are claimed.

UNITED KINGDOM

A British firm has succeeded in producing joists from small scantlings in a way that permits saving of 10 percent of the timber normally required, but it includes the saving of 42 percent of imported timber. The actual construction of the joists is simple, but it should be mentioned that the vertical pieces are glued to the rebates with synthetic resin glue warranted to withstand moisture and all weather conditions. Tests, made by the Belfast College of Technology showed that the joists actually had the characteristics their manufacturers claimed and that a great part of each joist could be constructed from short offcuts of homegrown timber having otherwise only fuel value.

UNITED STATES OF AMERICA

At the University of Washington, Seattle, United States of America, Professor L. Grondal has been running some interesting experiments in order to find possible substitutes for western red cedar, *Thuja plicata* Donn, in shingle manufacture. He cut shingles from Pacific silver fir, *Abies amabilis* (Dougl.) Forb., dipping them in a solution of dimethanol urea to reduce the hygroscopicity of the wood. After being dyed, those shingles are said to take on the exact appearance of red cedar, the color extending completely through the wood. Research is also being undertaken to see if silver fir may be used as a substitute for Ponderosa pine for apple shook.

An experiment recently carried out showed that after a fiercely flaming blow lamp was directed for 20 minutes full on the surface of Canadian red cedar shingles, the shingles tended to stifle and kill rather than kindle a fire. The fact that they are light reduces also consequential damage from roof collapse. Besides, a cedar shingle roof, when properly fixed, cannot deteriorate by decomposition or decay; all that can happen is a gradual wear of the shingles, which in the United Kingdom would require almost 60 years. Tests also show that cedar shingles are 21 times more waterproof than ordinary clay tiles, and that a roof of these shingles offers a greater security against storms and gales. The saving in timber for roof structure for a shingle roof compared with a tile roof averages 40 percent. A shingle roof has also an attractive appearance and does not need repairs throughout its life.

According to Mr. Tyler S. Rogers, president of the Producers' Council, modular co-ordination has been actively sponsored in recent years by the Producers' Council and the American Institute of Architects. The four-inch module which is basic to the entire project has been formally approved by the American Standards Association, and the dimensions of most masonry materials, of metal and wooden doors and windows, and of other products already are in production, with the result that the entire outer shell of masonry structures now can be constructed of materials whose dimensions have been co-ordinated. The Industry Engineered Houses, designed throughout on the modular basis, will account for a major part of savings anticipated in their building. The United States Department of Commerce has made a grant to the Modular Service Association to promote research on co-ordinated dimensions in the building trade and to make available to the public more quickly modular materials which will permit important savings in both material and labor.

AUSTRALIA

The Australian oyster industry is finding great difficulty in obtaining suitable stakes for the cultivation of oysters. It is considered that the thinnings from the cypress pine forests, *Callitris spp.*, might prove satisfactory, and 10,000 stakes have been delivered to the Division of Fisheries, Cronulla, for an extensive field trial. The demand of the oyster industry runs into some millions of sticks per year, and if the cypress pine proves satisfactory it will be possible profitably to thin the cypress pine forests and thereby perform a twofold service both to Australian forestry and the oyster industry.

Waste Utilization

AUSTRALIA

During the refitting of the 10,000-ton M.V. *Wanganella* a floor fill of considerable thickness was required during the erection of a deckhouse and the remodelling of two rooms into children's playhouses, in order to level off the deck plates before laying a linoleum mat. For these purposes a low density composition, combining resilience and sufficient strength to withstand any racking action in ship members caused by motion at sea, was demanded. It was established that sawdust cement, when carefully applied, could fulfill these requirements and, in addition, supply good sound and heat insulation for the crew quarters. In mixing and laying it, it was found that little variation from normal concrete procedure was necessary and that its cost compared favorably with other methods of overcoming the practical problems involved.

UNITED STATES AMERICA

A process has been discovered and recently patented in the United States of America for making synthetic wood from cottonseed hull bran and a resinous composition. The method consists of forming a board from cottonseed hull bran by pulverizing the bran and mixing it with a resinous compound from pine wood. The resulting material is then subjected to heat and pressure until a homogenous board is produced. The resinous composition used in the process is extracted from wood with a coal tar hydrocarbon practically insoluble in petroleum hydrocarbon.

A woodbase plastic lighter than cork has been announced in the United States. A "foamed" plastic, cellular cellulose acetate, it is so light that 4 cubic feet (0.11 m^3) can be balanced on the fingertips with ease. Yet the strength factor approaches structural dimensions, and it is claimed that luggage made with the new material as a core will support a man's weight. It is said to combine remarkable structural strength with virtually the same insulation against heat and cold as cork, balsa wood and other rigid insulating materials.

A new plant which will produce a new type of fiber board in an amount equivalent to 70 million board feet (165,000 m^3) of lumber is being constructed in the United States of America. The potential products to be made are structural insulating board and acoustic insulating board which require separate and different pulping processes. The goal to combine a preponderance of short fiber from Douglas fir, *Pseudotsuga taxifolia* Britt., with longer fiber to produce soft board of higher than average strength, has been achieved on laboratory scale. Not only the immediate utilization of edgings, trimmings, and waste from sawmills and plywood plants is contemplated but also the eventual use of other forest materials, such as thinnings taken from new growth on farm wood lots, etc. It is claimed that the plant will provide 35 percent more payroll, 35 percent more man hours of work, 35 percent more usable material out of every 1,000 board feet (4.53 m^3) of logs.

One of the American licensed producers of compressed logs has found, by use of a hot blast furnace and a system of cyclones, a means to reduce the moisture of the shavings and chips by 50 percent and to bring the moisture content down to the 6 to 10 percent required for the manufacture of the compressed log. The entire procedure is one of fast continuous circulation through the hot and cold cyclone systems. The new method speeds up production, as the complete circulation is made in a matter of seconds.

A device has been developed for making lumber products from wood waste. The new product is obtained from lumber scraps—bark, limbs, sawdust, and other waste parts. It can be made into any wood item now being produced from wood itself. Plants are being built in Detroit and New England, and plans are being made for constructing factories in England, Australia, and South America.

A method has been devised of making profitable use of wood waste by converting it into wooden costume jewelry. An American furniture manufacturer, in fact, rigged up an old press in the shop which had not been used for years and began punching out the jewelry, which includes animal head pins. In addition he is using his ring machine to turn out hundreds of wooden bracelets. The only additional expense has been the purchase of a few dies.

The Oregon Forest Products Laboratory reports conversion of Ponderosa pine waste into a fine hardboard and hopes to perfect a commercially feasible process. The Laboratory says the present process will work only on a larger scale than is possible in the eastern Oregon pine country. A million dollar investment and an output of 50 tons a day would be required. The laboratory hopes to develop a smaller scale process which could be used by eastern Oregon mills.

A new use for pine shavings and sawdust has been found in the manufacturing of fire brick according to a report of the South Carolina State Forestry Commission. The shavings and sawdust are mixed with clay before the bricks are formed and when they are baked in the kilns the shavings and the sawdust burn out, leaving the brick intact but much lighter and just as useful because of the air cavities.

At the Polytechnic Institute in Brooklyn, New York, a new process was discovered for manufacturing hard wallboard for panels, ceilings, furniture, ships' cabin bulkheads, etc., from a raw material consisting entirely of lingocellulose waste which preferably has been passed through a ⅛ inch (3 mm.) mesh screen or shavings, etc., preferably not exceeding 1/16 inch (1.6 mm.) in thickness with the addition of certain chemical plasticisers. These plasticisers cost about 35 cents per pound weight in the United States of America, but it appears that supplies could readily be produced in European countries where chemical factories exist. The process utilizes sawdust, wood shavings, chippings, cuttings, bark, etc. The cost of production largely depends upon the supply of labor and the extent of mechanization of handling appliances In America, it has been found that, using wood waste purchased at U. S. $7.00 per ton, hard wallboards 3/16 inch (4.8 mm.) thickness, could be produced at a factory cost of less than U. S. $0.025 per square foot (U. S. $0.025 per 0.09 m^2).

Personalities

Lord Robinson is shortly relinquishing his position as Director General of Forestry, United Kingdom, but will continue his chairmanship of the Commission for Forestry which he has held since 1932.

Mr. W. T. Taylor, now Deputy Director General, will take his place as Director General.

Major W. Newland Hillas was elevated from the Vice-Presidency of the Timber Trade Federation of Great Britain into the Presidential Chair. Major Hillas is governing director of W. N. Hillas and Company, Limited.

Mr. Norman A Wright will be the new Vice-President of the Timber Trade Federation.

Sir Edwin Plowden, whose appointment as Chief Planning Officer to the Government was announced, was formerly a member of the British Wood Pulp Association as a representative of Messrs. C. Tennant Sons and Company, Limited, of which firm he is a director. Sir Edwin, who was made a K.B.E. in last year's birthday honors, was chief executive of the Ministry of Aircraft Production during the war.

The death of Mr. Ernest W Tickle, editor of *Timber and Plywood*, has been annouced. A practical timber man with years of timber experience, he became editor in 1930 of that well-known British publication.

J. D. Long, for the past seven years on the staff of the Douglas Fir Plywood Association in Tacoma, Washington, has resigned to go to Colombia, South America, to assist in setting up a program of agricultural engineering for that country. The work is a part of the Colombian Government's postwar plan for the improvement and modernization of agriculture throughout the country.

Jan C. MacQueen, formerly with the British Columbia Forest Service, has joined C. D. Shulz and Company, Vancouver, B. C., foresters and forest engineers. In addition to general forestry and engineering, he will specialize in fire control problems.

Señor Silvestre Aguilar has been appointed Director General of Forestry and Hunting in Mexico.

Dr. Alf Langsaether and Dr. Elias Mork have been appointed Professors at the Norwegian Forestry Research Institute.

Mr. T. Ruden has become Chief of the Forest Tree Breeding Section at the Norwegian Forest Research Institute. Mr. Ruden has spent the spring and summer of 1947 in Sweden and Denmark for further study with regard to his new assignment.

Meetings and Conventions

The British Forestry Commission is sponsoring a conference to start 27 November 1947 in order to consider measures to be taken to prevent the introduction of *Ips typographus* and other insect pests with German timber imports.

The first meeting of a new organization called the European Federation of Wood and Packing Material Manufacturers was held at *Paris* 14 March 1947. Belgian and Dutch delegates participated and the British group announced its intention of joining the Federation. Monsieur Moretton was provisionally appointed president. The aims of the new organization were stated at its first meeting: distribution of raw materials, price schedules, and salary scales.

At the last meeting of the *French* Poplar Commission the suggestion was brought forward of creating an International Poplar Commission. The motion was sponsored by the Belgian, Dutch, and Swedish delegations as well as by a number of other countries. FAO has kept in touch with the French Poplar Commission and would gladly welcome a favororable outcome of the motion put forward at the meeting.

The Sixth Scandinavian Forestry Congress was held in *Norway* from 16 21 June 1947. The Norwegian Director of Government Forests, K. Sørhus, was appointed president. Mr. J. Mathiesen and Mr. Niels N. Ihlen were appointed vice-presidents. Mr. W. Opsahl of the Norwegian Department of Agriculture acted as secretary-general.

The Natural Resources Department of the *United States* Chamber of Commerce will sponsor five regional forestry conferences in 1947. The first conference was held at Portland 6-7 March 1947.

An American Lumber Congress—the first nationwide meeting for lumbermen to be held in 25 years—was held in Chicago, 16-18 June, sponsored by the National Lumber Manufacturers Association of Washington, D. C.

CONVERSION FACTORS

Adopted by FAO Forestry and Forest Products Division in June 1947. Tables on "Wood Measures" follow recommendations of the Statistics Conferences held in Washington and Rome in 1947.*

I. GENERAL MEASURES

Units of Length		Units of Area		Units of Volume	
1 inch	= 2.540 cm.	1 square inch	= 6.452 cm^2	1 cu. in.	= 16.39 cm^3
1 centimeter	= 0.3937 in.	1 cm^2	= 0.155 sq. in.	1 cm^3	= 0.061 cu. in.
1 foot	= 0.3048 m.	1 square foot	= 0.0929 m^2	1 cu. ft.	= 0.02832 m^3
1 meter	= 3.281 ft.	1 m^2	= 10.76 sq. ft.	1 m^3	= 35.31 cu. ft.
1 yard	= 0.9144 m.	1 square mile	= 259 ha.		
1 meter	= 1.094 yd.	1 hectare	= 0.003861 sq. mi.		
1 mile	= 1.609 km.	1 acre	= 0.4047 ha.		
1 kilometer	= 0.621 mi.	1 hectare	= 2.471 acres		
1 yard	= 3 feet = 36 inches	1 square mile	= 640 acres		

NOTE: For Wood Measures see. Table II, "Processed Wood" and "Roundwood," below.

Units of Capacity Liquid Measure		Units of Mass		Pressure	
1 cu. in.	= 0.01639 liter	1 pound	= 0.454 kg.	1 lb./sq. ft.	= 4.882 $kg./m^2$
1 gallon (U. S.)	= 3.785 liter	1 kilogram	= 2.205 lb.	1 $kg./m^2$	= 0.2048 lb./sq. ft.
1 gallon (imp.)	= 4.542 liter	1 short ton	= 0.9072 metric tons	1 lb./sq. in.	= 703.1 $gm./cm^2$
1 liter	= 61 cu. in.	1 metric ton	= 1.102 short tons	1 $gm./cm^2$	= 0.0142 lb./sq. in.
1 liter	= 0.2642 gal. (U.S.)			1 lb./cu. ft.	= 16.02 $kg./m^3$
1 liter	= 0.3170 gal. (imp.)	1 long ton	= 1.016 metric tons	1 $kg./m^3$	= 0.06243 lb./cu. ft.
1 gallon	= 4 quarts	1 metric ton	= 0.9842 long tons		

1 cu. ft./acre = 0.07 m^3/ha. 1 m^3/ha. = 14.29 cu. ft./acre

II. WOOD MEASURES

ROUNDWOOD

Product	Unit	Solid Volume Without Bark	
		Cubic Meters	Cubic Feet
Sawlogs	1,000 board feet	4.53	160
Pulpwood	Cord (128 cu. ft.)	2.55	90
	Stere (Raummeter) — coniferous	0.75	26.5
Fuelwood	Cord (128 cu. ft.)	2.12	75
	Stere — coniferous	0.70	24.7
	Stere — broadleaved	0.65	23.0

PROCESSED WOOD

Solid Volume of Lumber				Equivalent Solid Volume of Sawlogs	
Cubic Meters	Cubic Feet	Petrograd Standards	1,000 Board Feet Measure	Cubic Meters	Cubic Feet
1	35.3	0.214	0.424	1.67	59.0
0.0283	1	0.00606	0.012	0.0476	1.68
4.672	165	1	1.98	7.79	275
2.36	83.3	0.505	1	3.96	140

*Inches, feet, and yards are the U. S.:British units.

THE Nations accepting this Constitution, being determined to promote the common welfare by furthering separate and collective action on their part for the purposes of

raising levels of nutrition and standards of living of the peoples under their respective jurisdictions,

securing improvements in the efficiency of the production and distribution of all food and agricultural products,

bettering the condition of rural populations,

and thus contributing toward an expanding world economy,

hereby establish the Food and Agriculture Organization of the United Nations . . . through which the Members will report to one another on the measures taken and the progress achieved in the fields of action set forth above.

—*Preamble to the Constitution of the Food and Agriculture Organization of the United Nations*

FAO Member Nations

AUSTRALIA
BELGIUM
BOLIVIA
BRAZIL
CANADA
CHILE
CHINA
COLOMBIA
COSTA RICA
CUBA
CZECHOSLOVAKIA
DENMARK
DOMINICAN REPUBLIC
ECUADOR
EGYPT
FRANCE
GREECE
GUATEMALA
HAITI
HONDURAS
HUNGARY
ICELAND
INDIA
IRAQ
IRELAND
ITALY
LEBANON
LIBERIA
LUXEMBOURG
MEXICO
NETHERLANDS
NEW ZEALAND
NICARAGUA
NORWAY
PANAMA
PARAGUAY
PERU
PHILIPPINE REPUBLIC
POLAND
PORTUGAL
SWITZERLAND
SYRIA
UNION OF SOUTH AFRICA
UNITED KINGDOM
UNITED STATES OF AMERICA
URUGUAY
VENEZUELA
YUGOSLAVIA